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HENRIETTA SWAN LEAVITT.

By SOLON I. BAILEY.

Henrietta Swan Leavitt was born in Lancaster, Mass., on July 4, 1868, and died in Cambridge, on December 12, 1921. She was fortunate in her ancestry, coming on both sides from old Colonial stock. Her father was the Rev. George Roswell Leavitt, a descendant from Jordan Leavitt, who settled in Hingham in 1640. Miss Leavitt inherited in a somewhat chastened form the stern virtues of her puritan ancestors. She took life seriously. Her sense of duty, justice and loyalty was strong. For light amusements she appeared to care little. She was a devoted member of her intimate family circle, unselfishly considerate in her friendships, steadfastly loyal to her principles, and deeply conscientious and sincere in her attachment to her religion and church. She had the happy faculty of appreciating all that was worthy and lovable in others, and was possessed of a nature so full of sunshine that to her all of life became beautiful and full of meaning.

Miss Leavitt graduated from Radcliffe College in 1892. Later she spent several years as advanced student and volunteer research assistant at the Harvard Observatory, in travel, and in teaching. She became a permanent member of the Observatory staff in 1902, and thereafter was closely associated for the remainder of her life with Prof. Pickering, in the solution of problems especially connected with the determination of the photographic magnitudes of stars. Beginning work as an ordinary assistant in the measurement of variable stars on photographic plates, by her exceptional ability and intense application she soon became the head of the department of photographic stellar photometry.

A determination of the visual magnitudes of the stars had a very large place in the work of the Observatory during the first half of Professor Pickering's directorate. As soon as the need of photographic magnitudes became urgent, the importance of a standard sequence, from which the photographic magnitudes could be derived for stars anywhere in the sky, became evident. A sequence of stars of varying magnitudes had been early selected near the North Pole, and the determination of the magnitudes of the stars involved was assigned to Miss Leavitt. This work was carried out with unusual originality, skill, and patience. The preliminary results were published in Harvard Circular, No. 170, and the more nearly complete results in the

Annals, **71**, No. 3. This Polar sequence has now been measured by other astronomers. Slightly modified by the improvements of later methods, it bids fair to be of great and permanent value. As extended by a study of photographs made at Mount Wilson with the 60-inch telescope, stars are included from about the fourth to the twenty-first magnitude. The sequence thus covers an enormous range in brightness. The light of six million stars of the twenty-first magnitude is required to equal that of one star of the fourth magnitude.

An extension of this research is given in Annals, **71**, No. 4, for which Miss Leavitt determined the photographic magnitudes. This includes lists of sequences for all the forty-eight equal regions into which, for convenience of discussion, Professor Pickering divided the whole sky in 1884.

Another work of a similar nature is found in Annals, **85**, No. 1. In it are given standards of photographic magnitudes for the Astrographic Catalogue. Sequences of 15 to 22 stars were selected and measured over the sky with special reference to the zones assigned to the different observatories taking part in this international catalogue. The above treatise contains the sequences for northern zones. The southern portion was in progress at Miss Leavitt's death.

Much of Miss Leavitt's time in the last few years was devoted to the difficult problems of standard photographic magnitudes for Kapteyn's Selected Areas.

About 1906 a Durchmustering of variable stars was proposed at the Harvard Observatory. Somewhat later this was undertaken on plates included in the Map of the Sky, which shows stars to the tenth magnitude, or fainter. Fifty-five of these plates cover the entire sky, and many sets have been made on different dates. A comparison of the photographs of a number of these regions by Miss Leavitt led to the discovery of several hundred variables and other special objects. Among them were a number of stars of the Algol type. A discussion of ten of these is given in Annals, **60**, No. 5.

One of the most striking accomplishments of Miss Leavitt was the discovery of 1,777 variable stars in the Magellanic Clouds. These results were possible by photographs of long exposure made at Arequipa with the 24-inch Bruce refractor and forwarded to Cambridge. Some of these plates had exposures of from two to four hours and showed very faint stars, among which nearly all the variables are found. A discussion of the elements of all these stars has so far been impossible, but from a study of 25 of them, the important law was derived, that the length of period bears a definite relation to the absolute magnitude.

In addition to these larger labors, Miss Leavitt took part in various minor investigations. She gave considerable time to the discovery of new celestial objects. Altogether, she found 4 new stars, 2400 variable stars, or about one half of the known variables, and various asteroids and other objects.

Miss Leavitt was of an especially quiet and retiring nature, and absorbed in her work to an unusual degree. She had the highest esteem of all her associates at the Harvard Observatory, where her loss is keenly felt.

Cambridge, January, 1922.

SHALL WE ACCEPT RELATIVITY?

By WILLIAM H. PICKERING.

Three years have now elapsed since the Principle of Relativity was first announced to a startled public, as perhaps the greatest scientific discovery since the time of Newton. Little attention had been paid to it before that, outside of the ranks of professional physicists. Now that the glamour has somewhat subsided, it may be a good time to take account of stock, to see what evidence has meanwhile accumulated in its favor, and how far its supporters have increased among scientific men. Regarding the latter, the physicists it is believed support it as before. Among the astronomers its stronghold is undoubtedly in England. In America opinion is divided. Which way the majority vote would be cast it is impossible to say. On the continent of Europe I have found the Latins generally skeptical, while I understand that very few of the Germans take it seriously at the present time. Three years is of course too brief a time for any important discovery to win universal acceptance in science. Perhaps a generation may be taken as a fair interval, sometimes a little less, sometimes a little more. Therefore if its adherents have not increased in the past three years, or have even fallen off, that can hardly be counted very seriously against it.

Let us now see what evidence has accumulated with regard to it in the mean time. The Principle of Relativity is founded, as is well known, upon three statements by Einstein. The first is that "Every law of nature which holds good with respect to one coördinate system must hold good for any other, provided that the two systems are in uniform movement of translation." This is simple enough, and has been recognized for many years. Later, however, Einstein added a second to it, that "We should not be limited in any way in our choice of systems so far as their state of motion is concerned." This addition, or second statement, leads to the three well known astronomical predictions made by Einstein, which we shall deal with in this paper. The third statement is that "The velocity of light is constant with regard to the observer, no matter what his velocity may be, and no matter what the velocity of its source." The first portion of this third statement contradicts our common sense, and is the cause of the most

severe criticism of the theory. It does not appear necessarily to follow from the observations, and will be discussed in a separate paper.

We will now take up the three astronomical predictions which form the *only* concrete proof offered hitherto of the validity of the theory. The first, and what is generally considered as the most convincing proof, relates to the advance of the perihelion of Mercury. According to observation this perihelion advances at the mean rate of 574″ per century. According to theoretical considerations based on the attraction of the other planets, the advance should be only 532″, leaving an unexplained balance of 42″. Three different methods of accounting for this advance have been suggested. Both Herzer and Newcomb have shown that it could be fully accounted for if we assumed that the solar equatorial diameter exceeded its polar one by 0″.5. If this were the case, however, there would also occur a change in the inclination of Mercury's orbit, amounting to 3″ per century, which is quite inadmissible. A second suggestion was that the advance was due to meteoric matter lying within the orbit of Mercury, matter which was largely responsible for the phenomenon of the zodiacal light. This too was ruled out as being inadequate for the purpose. The third suggestion, which was in fact tried as long ago as the time of Le Verrier, was that the advance was due mainly to one or more small inter-Mercurial planets. This last has now been practically disproved by the lack of evidence of their existence at the time of various total solar eclipses, when they have been sought for by means of photography. Neither have they been detected in transit across the sun's disk since Le Verrier's time, in spite of the innumerable observations and photographs taken of the sun at the present day.

By means of the principle of relativity, without making any other assumptions whatever, Einstein computed that there should be an advance of the perihelion of Mercury amounting, as we all know, to 43″ per century, or within 1″ of the observed amount. This was considered to be a great triumph, and it was largely due to this success that the two expeditions were fitted out to observe the solar eclipse 1919. Nevertheless some doubters appeared. It was pointed out by the writer (*Scientific American Monthly* for April 1921), and later reprinted in "Einstein's Relativity," by Bird, p. 301, that the difference of 42″ between the observed and theoretical values of the advance, was based on the tacit assumption that the shape of the sun was a perfect sphere, and so produced no advance whatever in the position of the perihelion. Now we know that the sun revolves on its axis in about twenty-six days, and therefore cannot possibly be a perfect sphere. It may readily be shown that the resulting excess of the equatorial over the polar diameter should amount to 0″.04, a quantity which could hardly be detected by direct observation. Such an excess is one-twelfth of the amount necessary to cause the observed advance, and should therefore cause an advance of the peri-

helion of about 3".5 per century, reducing the difference between the observed advance and that due to gravitation to 38".5. There is thus a discrepancy betwen this figure and Einstein's result, of 4".5 or 10 per cent—a very appreciable difference.

Dr. Poor has more recently stated in the *Scientific American Monthly* for July (see also *Scientific American* for June 11, p. 468), that by correcting a slight error in Newcomb's calculations, the whole of the advance may be accounted for if we assume a suitable and not improbable density of matter in the region lying within the orbit of Mercury. Moreover, that such an assumption will materially reduce the deviations between observation and theory for the three other interior planets. Everyone who has observed a total eclipse of the sun must have noticed how black the moon appears as compared with the uniform light of sky in the regions surrounding the corona. That this effect is not due to contrast with the bright inner corona is clearly shown by photography. This uniform light can only be due to illuminated matter lying beyond the moon, matter so brilliantly luminous as to completely extinguish the zodiacal light itself. We therefore know that such matter certainly exists in considerable quantities within the orbit of Mercury, and must tend to accelerate the motion of its perihelion. Whether Dr. Poor's view that it is sufficient of itself to account for the whole discrepancy is correct, or not, there is no doubt that it must account for it in part, and consequently that Einstein's result differs very appreciably, more than 10 per cent from the required amount—a very unfortunate result.

TABLE I.

THE ECLIPSE OF 1919.

Location	Aperture	Focus	Plates	Stars	Deflection	Deviation
Principe	13	11	2	5	1".60	—0".15
Sobral	13	11	19	12	0.93	(+0.06)
"	4	19	8	7	1.98	+0.23

Let us now turn to Einstein's second proof, and consider what conclusions may properly be drawn from the results of the eclipse observations of 1919, that were so highly acclaimed at the time, as finally settling the authenticity of the theory in the affirmative. It will be recalled that two expeditions were sent out to observe this eclipse, one to Principe, Africa, and the other to Sobral, Brazil. Their equipment and results are shown in Table I, where the successive columns give the location, the aperture in inches of the telescopes employed, their focus in feet, the number of plates secured with each, the number of stars measured, the difference between their mean deduced deflection at the sun's limb and their true positions, and the corresponding deviations from the theoretical results. In the first and last line of the table this deviation is taken from Einstein's computed value of 1".75. In the second line the difference shown is from the value required by the Newtonian theory, 0".87. The results obtained with this telescope were rejected however, although

they were much the most numerous, because it was found that for some reason, supposed to be the heating of the mirror by the sun before the eclipse, the star images were slightly out of focus, and were therefore considered unreliable. The results with the two other telescopes were not very accordant, but the 4-inch secured the greater number of plates, and showed the greater number of stars. The results obtained with it therefore appear to be the more trustworthy. They differ from Einstein's prediction by 13 per cent, which is not very satisfactory.

The question now at once arises was it proper to reject utterly the results obtained with the second instrument, simply because the images were slightly out of focus. As many stars were photographed with it as with the two other instruments combined, and nearly twice as many plates were taken. The deviation from the theoretical Newtonian result was only 0".06, or 7 per cent, and is therefore better than that given by either of the other instruments. While those who examined the plates are certainly the best judges of them, yet to an outsider it does not seem wise to assign no weight to the careful and precise work done with the second instrument. It is not a case of simply one or two discordant results. If it was all to be rejected, this at least should have been decided before the results obtained with it were deduced. Had they been confirmatory, there is no doubt but that they would have been accepted.

It may be pointed out in this connection that in any photograph made with a mirror, the scale must always be uncertain, unless special precautions are taken to maintain the temperature of the mirror absolutely uniform for hours beforehand. This is because the scale does not depend upon the distance of the objective from the plate, but upon the location of the optical center of the combination. This may fall either behind or in front of the lens, depending on the curvature of the mirror at the time of the exposure. Telescopes furnished with mirrors are therefore particularly unsuited for an investigation of this character. It is a pity that this point, which I understand had been suggested, had not been fully appreciated before the expeditions started. The fact that eight out of the ten plates which were supposed to confirm Einstein were taken with an aperture of only four inches, while the focus of the lens was nineteen feet, renders it quite impossible to judge from their appearance whether they were in the proper focus of the combination or not. We must merely assume that this mirror remained flat. Whether the sun shone on it or not, its temperature was changing, and its curvature therefore was liable to variation, as anyone who has used a mirror of long focus at night must be well aware.

It therefore appears that little or no weight should be attached to the results obtained at this eclipse. This is a great pity since it occurred in a portion of the sky among the Hyades, where a con-

siderable number of fairly bright stars are found. Indeed it is the most favorable region in this respect in the whole ecliptic. It is hoped and expected that the results to be obtained at the next two eclipses will prove to be less open to criticism. It may be recalled in this place that the excellent results obtained by Campbell, with the Lick party in 1918, of which much less has been heard, did not confirm the theory of relativity.

With regard to the third test suggested by Einstein as suitable for the confirmation of his theory—the displacement of the lines in the solar spectrum, little need be said. It is now generally known that in no case has the theory been satisfactorily confirmed. The most favorable report comes from India, regarding which Dr. Royds has recently stated that the question was of great difficulty, observations were contradictory, and that final results had not as yet been obtained. At Mt. Wilson the wonderfully accurate measures of St. John are distinctly unfavorable.

Summarizing our conclusions, we may say that in the first test, that of the motion of the perihelion of the orbit of Mercury, the theory of relativity fails to give results in accord with the facts. Regarding the second test, the only result so far obtained is that it has now been clearly and satisfactorily demonstrated what not to do. The evidence so far regarding the third test is as we all know, and have seen, distinctly adverse. Perhaps we cannot do better than close in Dr. Einstein's own words. "If any deduction from it should prove untenable, it (the theory in its entirety) must be given up. A modification of it seems impossible without destruction of the whole."

Luxor, Egypt, February 6, 1922.

COSMIC CLOUDS.

By WILLIAM F. RIGGE.

In this age of large telescopes that are all exclusively photographic and devoted to the detailed analysis of the heavenly bodies, it would seem that visual observations and comprehensive surveys had been decided to be practically obsolete. It was therefore a great surprise, not only to the members of the Astronomische Gellschaft in Potsdam towards the end of last August, but to the astronomical world as a whole, to hear Father Hagen, of the Vatican Observatory, report that he had found the entire heavens visible to him very thickly overcast with more or less opaque and dark cosmic clouds, much as our own atmosphere is at times largely dotted with terrestrial ones. These dark clouds, of course, can betray their presence and their outlines only by the greater or less dimming effect they produce upon the luminous stars.

The first account in print of Father Hagen's great discovery appeared in the *Monthly Notices* of the Royal Astronomical Society for April, 1921, and was illustrated by a map of these clouds within a radius of 50° from the north pole. A second technical article of his is incorporated in the centennial number of the *Astronomische Nachrichten* of September, the frontispiece of which is a map 7 x 15 inches of the region between 3^h and $5^h\ 30^m$ right ascension, and 20° and 35° north declination. A popular presentation is to be found in the *Stimmen der Zeit* for last November.

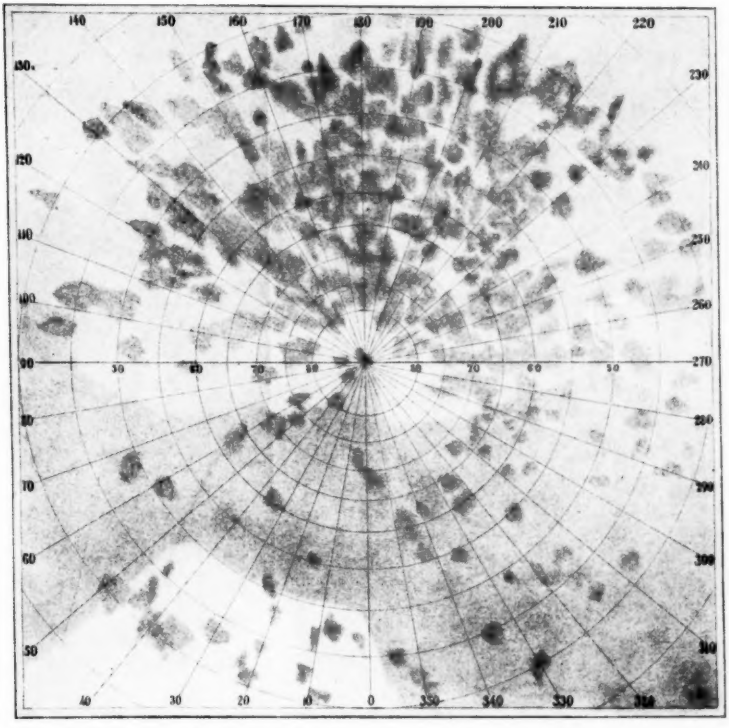
While Sir William Herschel in 1818 was probably the first to notice some of these dark clouds, and many isolated ones have since been shown on photographs, notably by Barnard, who published a list of 182 of them (Ap. J. **49**, 1919 p. 14), no one had ever made them the object of systematic research. To Father Hagen himself they obtruded themselves at first only as a by-product, while he was reobserving the nebulae in Dreyer's New General Catalogue for the main purpose of estimating their brightness. He met many of them also in the construction of his Atlas of Variable Stars, because every chart was compared at least five times with the sky, not only in different months, but also in different years, so that persistent dimming of the same parts could not possibly be of terrestrial origin. These parts are noted on the charts concerned.

Although the survey is not yet completed, it has already revealed its main features. In opposition to the prevailing view, the greater mass of these cosmic clouds lies outside the Milky Way. They cover the whole heavens, so that an entirely clear sky is very seldom met with, and in thicker or thinner groups they form a continuous road or way, which might be called the Nebular Way. This runs on both sides of the Milky Way, and is much more extensive than the latter. Its density appears to follow the law that it diminishes with distance from the pole of the galaxy, but this is only an optical illusion, because contrast with a bright background exposes these clouds better to our view

The behavior of the luminous nebulae towards the Nebular Way is very remarkable, since they are most abundant just where the dark clouds are most dense. The former are to be found mostly on the borders of the latter. The stars however do the reverse, so that the more densely the stars cluster, the clearer the sky is from these clouds. In fact a perfectly clear sky is generally to be seen only in the near neighborhood of a cluster of stars.

It often happens, too, that sharp separations of very dark and bright fields are set with rows of stars, which are generally equally bright and equally distant from one another. These rows are especially noticeable when they form a semicircle or an oval. The enclosed field is then generally much brighter, like an island in the cloudy sea of the Nebular Way.

PLATE XVIII



COSMIC CLOUDS OBSERVED BY REV. J. G. HAGEN, S. J.
Reprinted from *Monthly Notices* R. A. S., Vol. LXXXI, p. 449, Apr. 1921

Although conclusions are yet perhaps premature, they may serve as guides for future research.

1. One overpowering impression, says Father Hagen, which the cosmic clouds make on the observer, is that the diffused nebulae which appear to us bright, like those in Orion and around the Pleiades, do not shine in their own light, but in the reflected light of neighboring stars. The same holds for the nebulous atmospheres in which a bright central nucleus is involved, except, of course, the planetary nebulae.

This impression leads at once to the conjecture that the stars were formed from these clouds, and that the Milky Way has made a cavity in the surrounding ocean of primitive matter. The isolated nebulous veils which are still seen along the Milky Way are like the residues left over from the process of concentration.

This conjecture fits in well with Lockyer's and Russell's theory concerning the process of the evolution of stars, which maintains that a star begins its existence as a giant, as the expression is, with a very low density, almost cold, and shining with a red color. Continued contraction increases its temperature, until in the prime of its life, it is a perfectly white star. As the contraction continues, the generation of its heat becomes less than its loss by radiation, the star becomes colder and denser and smaller, a dwarf, and in its old age shines with a red light. The primordial matter necessary to begin this cycle is neatly furnished by the dark cosmic clouds.

2. This theory has the advantage of answering definitely the long-standing question, why the spirals seem "to avoid the Milky Way." Being associated, as we have seen, with the densest cosmic clouds, they surround the galactic cluster in all directions. If we assume the mean equatorial diameter of the galaxy, with Professor Charlier, six times as large as the polar diameter, and if we attribute the same dimensions to the hollow of cosmic matter in which the Milky Way is embedded, the light coming to us from the spirals situated around the galactic equator will be thirty-six times less than from the poles, and hence too faint to impress an image on the photographic plate.

3. On the other hand, the idea of a permanent cavity in which our galaxy should rest, seems to encounter a serious difficulty in the very high radial velocities found for spirals. But as the apex of their motions is close to the Milky Way, it points to a rotation of the galaxy in its own equatorial plane. This rotation agrees perfectly with the theory of our stellar system being the result of concentration from previously existing cosmic matter, and favors the idea that the spiral nebulae are cosmic formations outside and independent of our Milky Way.

DEMONSTRATION APPARATUS IN DESCRIPTIVE ASTRONOMY.

By DINSMORE ALTER.

There are perhaps few of the sciences which place the student upon almost entirely new ground as early in his first course as does astronomy. His thoughts have been of things in the home and, at most, limited to the few thousand miles of our earth, and suddenly he is talking of trillions of miles, of rotations and revolutions, of precessions and nutations, of variations of latitude and of aberrations. He swims giddily in a haze of new ideas and finds few straws of his former experience to aid him. Despite these difficulties we continue to tell him more new facts and to draw on the board more representations, often poorly made, of three dimensional space,—at best thoroughly intelligible only to the student who has had some training in their use.

I desire here to give the results of an attempt to aid the student in visualizing the most difficult parts of his beginning work. The devices need little explanation, the photographs showing to anyone acquainted with astronomy their respective advantages. The last object differs from the others in not being a piece of demonstration apparatus.

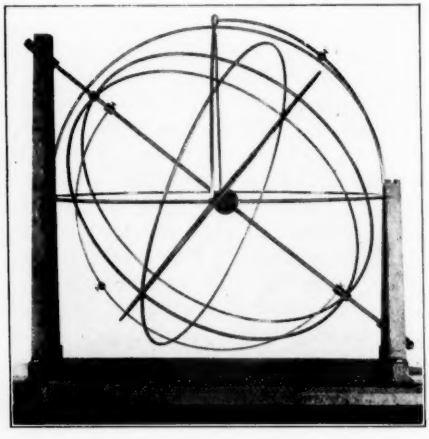


Fig. 1

Figure 1 represents a coördinate sphere, a slight modification of one built by the department of Civil Engineering at the University of California. The circles are each approximately 36 inches in diameter, some being enough smaller to turn within the others. The

horizon, meridian and prime vertical are painted red and fastened rigidly to the base. A movable vertical circle, with an adjustable star, swings from the zenith. All circles of the equator system are painted green and turn about the earth's axis. Of these are shown the equator, the equinoctial and solstitial colures and an adjustable colure with movable star. It is necessary to have quite a strong clamp for this circle. The ecliptic is shown in yellow and the poles of the ecliptic as yellow spots at the proper places on the solstitial colure.

Fig. 2

Figure 2 is another coördinate frame, designed to use in conjunction with a gyroscope in explaining precession. I have always found it very difficult to make more than a very small part of the class understand the effects of precession on right ascension, declination and celestial longitude. The equator system is painted green as in the first frame and the ecliptic yellow. It is important to use the same color scheme on all the devices. The equator rides on the ecliptic as shown in the photograph and can be pushed backward easily, maintaining always a constant obliquity. Stars can be clamped in any desired position with reference to the poles and the vernal equinox, and rough quantitative results secured for right ascensions and declinations of known stars at any future date.

Aberration is one of the new things in astronomy to bother the novice. I believe that I have had less success in teaching the fundamentals of this subject than of any other. Figure 3 shows a device

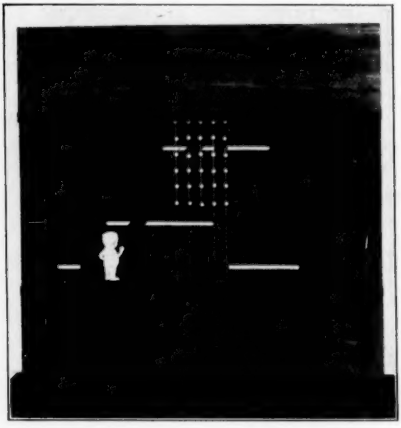


Fig. 3

to explain the mechanical results of aberration. A section of the earth, with a young astronomer (used to attract the attention of any sleepy students) and a telescope tube are carried horizontally across the board when the crank is turned. Light waves, represented by small balls at equidistant intervals, descend vertically and it is necessary to tip the telescope in the direction of motion that they may pass down the tube.

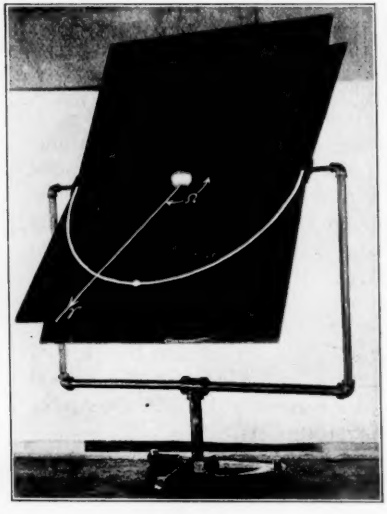


Fig. 4

Fig. 5

Figures 4 and 5 are entirely self-explanatory. I have never seen a piece of apparatus designed to explain the elements of a planet's orbit, but the need is so obvious and the apparatus so simple that it must surely have been used by a number of teachers. The ecliptic is again painted yellow, the orbit plane of the planet some color not previously used and the angles out of these planes a different color.

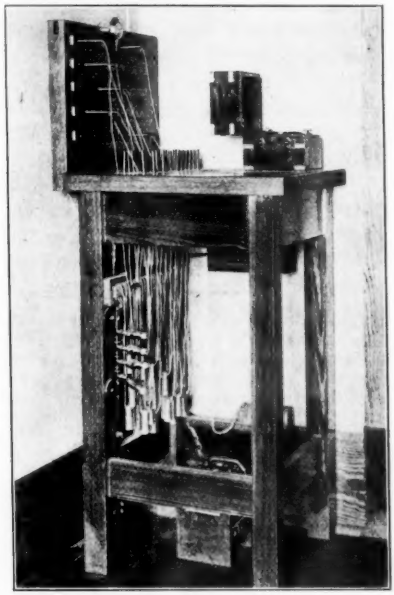


Fig. 6

There is perhaps nothing new in Figure 6. However, it has some advantages not possessed by a great many switchboards in use. At Berkeley three transits and chronographs were often in simultaneous use. It was desired not to use the Riefler any more than necessary with the chronographs. Since we had only one sidereal chronometer the purchase of one or two more seemed necessary. This switchboard was designed to avoid that expense. The one at Berkeley is larger than the one shown and is made of marble instead of wood but no photograph of that one is at hand. The two top buss bars are connected to a four volt storage battery. In order to make it "fool proof" four lamps in parallel are placed in series with these bars. The two lower buss bars are connected to a dry cell. The others are merely receptacles for the jacks from instruments and keys. On the Berkeley switchboard an additional pair of buss bars is connected to a six volt battery. Each key and instrument in the

building is connected to two jacks, placed one in front of the other on the board. Weights hold the cords down. In order to use one chronometer for two or more independent records it is necessary to put the chronometer and the light end of the relay in series (a rheostat is always in series with the chronometer to prevent any possibility of too much current passing through it) and then plug the end jacks in the two volt buss bars. Each telegraph key is then put in series with its chronograph and these series connected in parallel with the heavy end of the relay. The end jacks are plugged in the four volt buss bars. Of course if one is willing to connect a four volt circuit directly to his chronometer the connections will be simpler and the errors of the relay avoided.

University of Kansas, 1921, October 13.

HOW TO KNOW THE HEAVENS.

By GILBERT P. CHASE*

> Canst thou bind the sweet influences of the Pleiades
> Or loose the bands of Orion?
> Canst thou bring forth Mazzaroth in his season
> Or canst thou guide Arcturus with his sons?
> Knowest thou the ordinances of heaven?

Being a navigator myself I know that to the deep-sea mariner a knowledge of the heavens is indispensable. To those in other walks of life a familiarity with the celestial bodies may prove useful as well as interesting. Writers of stories, for example, may save themselves from such errors as having the mid-winter stars "twinkling merrily" in the July firmament.

Of all the star charts and spherical representations of the heavens that I have inspected, I find the United States Hydrographic Office Chart 2100 the most convenient and the most satisfactory in every way. This chart is a plan of the constellations of the Northern Hemisphere. There is a similar one for the Southern Hemisphere, 2101. These charts as well as many others may be inspected at any of the Branch Hydrographic Offices, of which there are sixteen in our seacoast and lake cities. That at New York is in the Maritime Exchange Building, 78-80 Broad Street. These Government offices have nothing for sale; they give out information useful to mariners and others interested in nautical affairs. Charts and Nautical Almanacs may be purchased from the agents, of which there are sixty-two in the cities of this country, and thirteen in the cities of foreign countries. The list of agents appears on the weekly Hydrographic Bulletin. No agent is permitted to charge more than the price printed on each publication. The price of the star chart is twenty cents; of the Nautical Almanac, twenty-five cents.

* Lieutenant Commander U. S. Navy, Retired.

From this point I will proceed as if the reader were provided with the star chart and Nautical Almanac. I will assume that the reader will find the explanation on the chart sufficient, and that familiar with its use, its merits will be apparent. Having plotted on the chart the Sun, Moon, and Planets, which appear to move among the fixed stars; and the meridian and zenith indicated as explained, then the heavens may be compared with the chart and the chart with the heavens, as the plans with the building. To every change in latitude, to the ever-changing hour of observation, and to every movement of the heavenly bodies, this chart may be brought to correspond. Herein lies its great advantage over the map which gives the aspect of the heavens for a particular time and place.

The way to identify the fixed stars is to work from the familiar to the unfamiliar. Most people living in the Northern Hemisphere become familiar with "The Dipper" and "The Pointers" to the North Star early in life. This constellation of Ursa Major is a typical example of the grouping and alignment of stars which enable us to pick out other stars until they become readily recognized by general familiarity. Following the handle of the dipper leads to Arcturus. Keeping on and bending the handle a little more we come to Spica. The two stars in the top of the dipper point to Capella, and the two on the opposite side to the handle lead to Regulus. Sirius, the largest and brightest of all the fixed stars, is on line with the belt of Orion. Other alignments may be traced in the same way. Algol, Capella, and Pollux are in line, or nearly so. Of all the constellations Orion is the most conspicuous. In this group there are two stars of the first magnitude and five of the second. The arrangement is striking. Aldebaran is part of an "A", as shown on the chart. When the smaller stars are not obscured by thickness in the atmosphere, or obliterated by moonlight, Vega is seen accompanied by two little stars forming with it a small equilateral triangle. Under conditions of good visibility, Capella appears attended by a slender isosceles triangle of smaller stars. Other groupings will be apparent as you look for them.

Another means of distinguishing the fixed stars is the magnitude, which is indicated on the chart. The stars all shine with a white or nearly white light, some having a noticeable blueish or reddish tinge. Antares, Arcturus, and Aldebaran are prominent "Reds," while Vega is Queen of the Blues.

In order to get a definite conception of celestial location it is necessary to have a practical understanding of Declination and Right Ascension, just as it is to specify the location of places on the earth by means of the latitude and longitude. The Declination of a heavenly body is the angular distance North or South of the Celestial Equator. The Celestial Equator may be defined as the intersection of the plane of the earth's Equator with the Celestial Sphere. In order to

trace mentally the Celestial Equator across the heavens, it is well to remember the rule that the latitude of the place is equal to the altitude of the elevated pole and to the Declination of the zenith. The North Star indicates the North Pole of the heavens. The Celestial Equator is ninety degrees from the pole, measured on any great circle passing through the poles. One point on the Celestial Equator is found by estimating on the meridian the angular distance from the zenith equal to the latitude of the place. Of course there is no visible indication of the Celestial Equator itself. On a starry night the Equator may be fairly well tracked across the heavens by means of the stars that lie on or near it, the most conspicuous mark being the belt of Orion.

Most of us associate the time of day with the hands of a watch or clock which point out the hours. Longitude is time; likewise Right Ascension is time. To lay out the hours of Right Ascension over the heavens at night I look first to The Dipper. The Pointers are in 11 hours of R. A. The side near the handle is in 12 hours. This same great circle becomes on the other side of the pole the "Zero Hour" of R. A., and passes through Beta Cassiopeiae and Alpha Andromedae. Looking at the North Pole and The Dipper we find that the R. A. increases in the direction going from the pointers to the handle. Thus we see that the hours of R. A. are laid out in the clockwise direction or from west to east, as the book tells us. It is well to remember the R. A. of a few familiar constellations, roughly. I have it pretty well fixed in my mind that Orion is not far from 6 hours of R. A., and that Vega is somewhere in the neighborhood of 18 or 19 hours. Now having the heavens marked out for us as it were, in lines or circles of R. A. and Declination, we will have some idea of how to locate the heavenly body whose co-ordinates of R. A. and Declination are known to us.

The casual observer does not think of the sun as apparently moving about among the fixed stars, because when he sees the sun he does not see the stars, and when he sees the stars he does not see the sun. But if he will plot the position of the sun on the star chart from time to time, he will be enabled to follow its course among the stars, the same as for the moon and planets which he actually sees at night in company with the stars. For the sun I have no comment except that many of us Americans may not be as much accustomed to "the dawn's early light" as our National Anthem might lead one to believe. As to the moon I might say that it is often visible in daytime, though unobserved.

In many ways the planets are the most interesting of all the heavenly bodies. The constellations have retained their original shape, the fixed stars have remained in their same relative positions since the days of primitive man. But the planets have never ceased to move about, lending a varied aspect to the heavens. Lately I have observed all four of the planets ordinarily visible to the naked eye,

Venus, Jupiter, Mars, and Saturn, in fairly close company with each other in the eastern sky. The star chart is particularly useful in locating and identifying Mars and Saturn. In size and appearance Saturn presents very little difference to some of the first magnitude whitish stars such as Procyon. Mars, though ruddy, is not much more of a "Red" than Aldebaran or Arcturus. When once familiar with the appearance of Jupiter, that planet is not likely to be mistaken for a fixed star; but when Venus is not around to speak for herself, Jupiter may be clothed with the attributes of his fairer sister. Venus is by far the most conspicuous and the most beautiful of all the stars and planets. Like most things of beauty, it is not exposed to view so much as less attractive objects. It is never seen in the middle of the night. It adorns only the pre-daylight or evening sky. At times it is too near the sun to be seen at all. More than once have I been struck with the amazing beauty of this celestial jewel. Wending our way homeward on the transport, a dark and lonely ship upon the dark and lonesome ocean, the heavens obscured by black and threatening clouds, Venus suddenly burst through a rift in the blackness, a magnificent diamond set in a patch of azure sky, scintillating in the light of Heaven. Right then and there I felt that I had never beheld in this world a thing more beautiful.

Boonton, N. J., 2 December 1921.

THE DURATION OF SUNRISE AND SUNSET.

By WILLARD J. FISHER

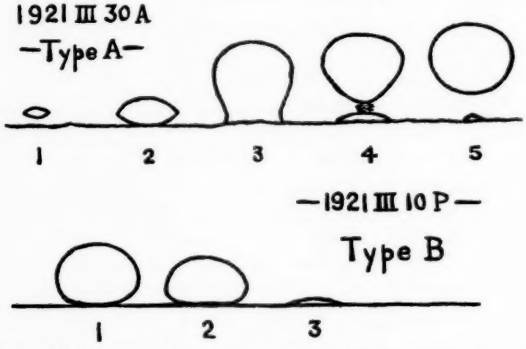
My attention having been accidentally directed to the matter, I have made observations for the purpose of comparing the observed duration of sunrise and sunset with the duration computed from geographical position and Nautical Almanac data, and have now 79 complete observations, made mostly with marine horizons on Manila Bay, the China Sea, the open Pacific, Vineyard Sound and Buzzard's Bay, with a few made with land horizons. The view points have been from sea beach to 1512 meters elevation.

There seem to be two types of marine sunrise and sunset, one, type A, about twice as frequent as the other, and accompanied by horizon mirage. The small figures accompanying this, sketched large from photographs made at Woods Hole, show the characteristics of the two types, which are described with historical details in POPULAR ASTRONOMY, **29**, p. 251 ff, 1921, May; and, with theory and methods used, in *Philippine Journal of Science*, 17, p. 607-614, 1920.

The time observations, made with field glass or telescope, stop-watch and ordinary watch, show that with type A there is on the whole a slight excess of observed duration over computed, amounting for 44 cases to 0.55 per cent; a few of the cases give small deficiencies. This

may be perhaps explained by atmospheric dispersion. Type B, however, always gives excess, sometimes remarkably large, even to 2 min., or 68 per cent, with an average excess for 22 cases of 12.3 per cent hard to explain.

Records of duration of sunrise and sunset are almost nonexistent; a careful search, with inquiries of several prominent astronomers, has failed to produce more than about half a dozen, mostly made by Le Gentil at Pondichryé in 1769, while on his transit of Venus expedition. While he made no such use of them, on computing they give results in agreement with the above. It would seem perhaps worth while for others to take the matter up, and record and publish *at least* date and



hour, geographical position, nature of horizon, duration, and type or form of disk. The horizon should be quite level and distant, if at all irregular. Naturally the best horizon is that of the sea or a large lake; but I have reason to believe that the results of observing with a distant level land horizon might be sometimes quite extraordinary.

While the sun is the source of light in such observations, and the Nautical Almanac (cost 15 cents) and four place logarithms have to be used in the computing, the subject is not astronomical but meteorological, and I suppose has to do with temperature distribution in the atmosphere. We have here one of those residual phenomena whose study may lead to something, and which can be forwarded by amateur observers, the more and the more widely scattered the better.

The table following was made thus: from table VI in the American Nautical Almanac, for each date and latitude indicated, the hour of sunset on the meridian of Greenwich is taken and corrected for equation of time, giving an hour angle precise within 1 m. or 15′, (as both local mean time and equation of time are rounded off to the nearest minute.) From latitude, declination and this hour angle the semi-duration of sunset in arc minutes is computed by the differential formula

$$(1) \quad dP_1 = \cos h \, dh / \cos \phi \cos \delta \sin P_1 ,$$

in which P_1 = hour angle, h = altitude of sun's center, ϕ = latitude, δ = declination, dh = sun's semidiameter. As the hour angle found from the Nautical Almanac is for the end of sunset, it is corrected by subtracting this approximate semi-duration, and the final value in mean time seconds found by

$$(2) \quad dP = 8 \cos h \, dh / \cos \phi \cos \delta \sin P ,$$

in which all sines and cosines refer to midsunset, declination and equation of time being constant within 0°.1 or 1 m.

For computing a very good ten-inch slide rule was used, which gives results as good as the Almanac hour angles will allow, and good enough for rough comparison with observed durations. (In careful study of the effects of atmospheric changes on sunset duration, one would compute each sunset separately, with exact hour angles, formula (2) and four place ligarithms.) In copying, the slide rule results are rounded off to whole seconds.

In a most unfavorable case, winter solstice and latitude N. 60°, 1921, assuming the data of Table VI, American Nautical Almanac, (given on p. 156. 1922,) the error of computing may be tested. Computing the hour angles for the beginning and end of sunset by the sine formula for time sights with declination and equation of time for the moments, and six-place logarithms, they are 42° 15′ 16″.4 and 43° 59′ 14″.4; the local mean times corresponding are $2^h\ 47^m\ 37^s.0$, $2^h\ 54^m\ 33^s.0$; the duration of sunset is $6^m\ 56^s.0 = 416^s.0$.

The mean hour angle is 43° 07′ 15″.0; using this in the differential formula (2), four place logarithms give $415^s.5+$, slide rule, $415^s.+$; so that the differential formula is in error by less than $\frac{1}{2}^s$, or less than $\frac{1}{8}$ percent.

By slide rule computing of the differential formula, with the hour of Table VI, $2^h\ 54^m$, the hour angle at end is 43° 45′, first approximate semi-duration 51′.3, final midsunset hour angle 42° 53′+, final computed duration $417^s.5$. This is an error of $1^s.5$. The result for the corresponding date of 1922, given in the table following, 414^s, differs on account of a slight difference in the equation of time.

For lower latitudes the error grows smaller, as sin P nears 1 and becomes insensitive; e. g., for the same date in 1921 and N. 45°, six place logarithms give $221^s.5$, four place, $221^s.7+$, slide rule, $221^s.5$.

For latitudes and dates intermediate among those of the table, and for other longitudes, linear interpolation suffices about as well as it does for the hour of sunset in Table VI, except that the date intervals are much longer; sunrise durations may also be interpolated.

While the dates are for 1922, the values given should be good, within their limits of error, in other years as well.

Examination of the table, or of a graph of the same, shows that during the year, for any latitude there are two maxima, about the solstices, and two minima, about the equinoxes. The maxima are sharper

than the minima. In low latitudes the summer maximum is less than the winter, due to the smaller semi-diameter of the sun; but in high latitudes, beginning above N. 52, this is reversed, due to the unsymmetrical and exaggerated effect of refraction, which makes the sines of summer solstice hour angles less than those of the winter solstice. At the autumnal equinox the duration is somewhat less than at the vernal, due to less semi-diameter; this holds for all latitudes where the term sunset has any meaning. Elevation above sea-level would have an effect like refraction.

THE DURATION OF SUNSET.

1922

Lat. N.		0°	10°	20°	30°	35°	40°	45°	50°	52°	54°	56°	58°	60°
		s	s	s	s	s	s	s	s	s	s	s	s	s
Jan.	1	142	144	152	168	180	197	220	253	270	292	319	356	406
	15	140	142	150	165	177	192	213	243	258	277	300	328	367
Feb.	1	136	138	146	160	170	184	203	226	239	254	271	292	318
	15	133	135	142	155	164	176	193	214	225	237	251	267	287
Mar.	1	131	133	139	152	160	171	186	205	215	225	237	251	267
	15	129	131	137	149	157	168	182	201	209	219	231	243	258
Apr.	1	129	131	137	149	158	169	182	202	210	221	232	245	261
	15	130	132	138	150	159	171	186	207	216	228	241	255	273
May	1	132	134	141	154	164	177	192	217	229	243	258	278	300
	15	134	136	144	158	169	183	203	230	244	261	281	306	338
June	1	136	139	146	163	174	192	212	244	262	283	309	345	394
	15	138	140	148	164	178	194	218	252	272	295	327	368	429
July	1	137	140	148	164	176	193	216	251	268	292	322	364	422
	15	136	138	145	161	173	188	209	242	258	278	304	337	383
Aug.	1	133	136	143	156	168	181	201	227	239	256	275	298	293
	15	131	133	140	153	162	175	191	214	226	238	254	272	294
Sept.	1	128	131	137	149	158	170	184	204	213	224	237	251	268
	15	128	130	136	148	156	167	181	199	208	218	229	242	257
Oct.	1	128	131	137	148	157	168	182	200	208	218	229	242	257
	15	130	132	139	151	159	171	186	205	214	225	237	251	267
Nov.	1	134	136	143	156	164	178	195	217	228	241	256	274	295
	15	137	139	146	159	171	185	204	230	243	259	277	300	329
Dec.	1	140	143	150	166	177	193	214	245	261	281	305	336	376
	15	142	144	152	168	181	197	220	254	271	293	322	359	411
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mar.	21	129	131	137	149	157	168	182	200	209	219	230	243	257
June	21	138	140	148	164	177	194	217	253	273	297	328	370	434
Sept.	23	128	130	136	148	156	167	181	199	207	217	229	241	254
Dec.	22	142	145	153	169	181	198	222	255	273	295	324	362	414

Since even constant refraction may thus reverse the effects of changing semi-diameter, it is clear that varying refraction must have considerable effect on the duration of sunset. In studying this effect, which led to the construction of the table, it is best to obtain the hour angle directly with a watch; for when the time-sight formula is used an assumption has to be made about refraction, and an error in this assumption may considerably affect the hour-angle and so the computed duration. Between the tropics this error is of less account than in higher latitude; but it is eliminated by the use of a watch.

Cambridge, Mass., Sept. 15, 1921.

A LETTER OF JOHN KEPLER.

By FLORIAN CAJORI.*

A hitherto unpublished letter of John Kepler, the astronomer, cannot fail to be of interest to scientific readers. It deals with little things at a time of stirring events. The Thirty Years' War was in progress. Gustavus Adolphus was soon to enter upon his military march into Germany. Wallenstein was at the height of his power. Believing in astrology, he interested himself also in astronomy and became the patron of the greatest astronomer of his day—Kepler—who was expected to exercise his genius upon astrological prediction and was enjoined "ganz fleissig" to cast certain nativities. Kepler's connection with the haughty general is a story by itself. Before 1628 the great astronomer was court mathematician to Ferdinand II, Emperor of Germany. The Emperor's exchequer being low and Kepler's salary 12,000 florins in arrears, arrangements were effected by which the back salary was to be paid by Wallenstein, and Kepler was to move to Wallenstein's dominion, Silesia, and there, in the town of Sagan, to continue his studies in astronomy and astrology. In 1628 Kepler's large family of eight members arrived at Sagan. Wallenstein provided a printing press from which appeared the second and third parts of Kepler's *Ephemerides*, also his *Sportula* and his comments on a letter from a Jesuit in China, dealing with the reform of the calendar which had been a subject of dispute among Catholic and Protestant theologians, and now interested even the court of Cathay. Kepler's "commentatiuncula" on this topic were written in 1627, but the appendix that followed bears the date "15 Jan. 1630," apparently the day preceding the writing of the letter which we print. As seen from that letter, the printing press threatened to become to him a financial liability. Moreover, the 12,000 florins back salary remained unpaid and Kepler found it difficult to support his large family. So, in 1630, he decided to present his case before Emperor Ferdinand II who was holding a convocation of the Reichstag, or assembly of German princes, at Regensburg. In the fall of 1630 Kepler started on horseback upon the long journey to Regensburg. On his way he stopped a few days at Leipsig, at the home of his friend Philip Müller, professor of mathematics and physics at the University, the same man to whom, eight months previously, he had addressed the letter which we print below. Kepler, always frail in body, arrived in Regensburg physically exhausted, and died a few days later, the $\frac{5}{15}$ November, 1630.

The letter which we reproduce deals largely with the efforts to secure paper for the astronomical publications. Difficulties is securing

*University of California.

paper had been encountered also by Kepler's great predecessor, Tycho Brahe, who finally erected a paper mill of his own near his Observatory of Uraniborg.

The original letter of Kepler is in the Dreer Collection of Autographs, kept in the Library of the Historical Society of Pennsylvania. The date of the letter is expressed in the manner customary at that time, signifying in this case "Jan. 16, old style, or Jan 26, new style." The letter was directed to Philipp Müller, as is shown by the address written on the back of the original document. Bartsch, who is mentioned in the letter, was the astronomer Jakob Bartsch who assisted Kepler at Sagan and married his daughter Susanna. Hoefelderus or Hohenfelder was an Austrian nobleman who had been a student with Kepler at Tübingen. There occur in the letter the names of the towns of Leipsig, Prague, Sagan, Görlitz, Gitsch, Lauban.

The following is a translation[1] from the Latin:

$\frac{16}{26}$ Jan., 1630.

Hearty Greeting.

My distinguished friend,

I have received three letters, 20 and 26 Dec. and 4 Jan. All contain a most pleasing proof of the duties and service undertaken by you. It is enough of a reply to them for you to know that they have been delivered. As to the rest of the business, which, as before (above) is common, I refer to you, so that with sufficient information light may shine upon you in the matter of procuring paper. It was (only) on Jan. $\frac{7}{17}$ that at last there were delivered to me eight rolls of the larger paper of Prague, of a somewhat narrower form than was yours from Leipsig, which was sent for the Sportula; but if you have a copy of the Sportula in the other paper of Prague, that remains even now the form. There is still the additional promise of 12 rolls, already let out by the Gitsch House. Do you, therefore, first of all look to your indemnity, I may add, to your reputation, if you are giving security for the paper which the Grossiani have from you. In addition, if the matter is still in an early stage, (make sure?) that it will do all that it has undertaken. For although I begged the House of Gitsch to send 50 florins to Leipsig for the paper which I there procured as a secondary supply, still they sent no reply. And so for that which now you have either bought (back) or contracted to be made, I shall have to settle at my own expense.

Before the day named we took a Chinese letter, which was to be set forth (published) on the writer's small paper accompanied by my notes. We halted at the dedication, for both the jokes made and the occasion of the title meant nothing to the world in general. As soon as the paper was received, we attacked the Ephemerides, and now we have two pages, one for 1630, one for 1631. For as to 1630. Bartsch after all sent one-half back from Strassburg promising

[1]We are indebted for this translation to Professor H. R. Fairclough of Stanford University, who took great interest in this autograph letter, some parts of which are very difficult to make out.

to send the other half when the post was made up. Hoefelderus also reported that a volume had been taken to your master courier and since it was his own wish to undertake this when leaving the Görlitz messenger had already gone off with it. This volume I earnestly hope that I shall later recover. Or if he has not half of the Ephemeris, still one Lauban messenger will bring it, for the second month on his run now coming to an end.

As to the Leipsig paper, if any is now ready, I will reserve it for notes, distributing it into as many page-parts as I think one copy will consume. Enough of the Prague paper has been brought for the Ephemerides. Diligence, however, will be needed in making the combinations, if they are to unite four impressions in the larger form. The driver is in a hurry. Pardon my brevity. My earnest and respectful thanks to Mr. Apianus for 2 rolls. Of course I will ask the drivers from Vratislana (?) to present themselves in season.

Farewell.

Sagan, $\frac{16}{26}$ Jan. 1630.

Cl : ex : I

Yours respectfully,

J. KEPLER,
Mathematician.

PLANETARY CONFIGURATIONS.

By FREDERIC R. HONEY.

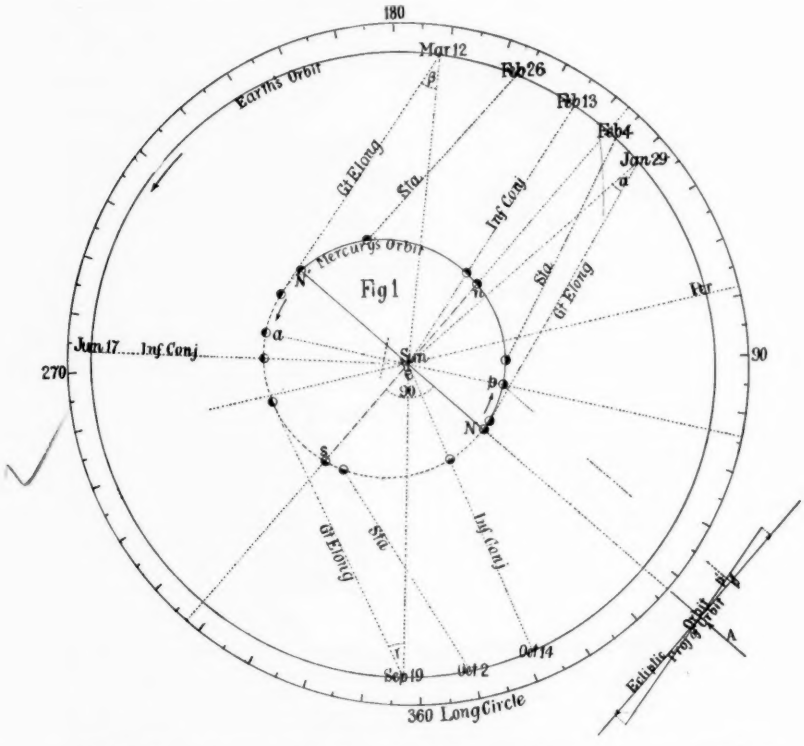
There are few studies in which the value of the graphic method is more apparent than in that of Astronomy. This is especially true in the beginning of the study, when it is important that the student should become familiar with the elements of the solar system. The drawing board may be employed to great advantage in the representation of the relative positions of the sun, the earth, the planets, and the periodic comets. The orbits are easily plotted, and the planets' or comets' positions for any assigned dates may be clearly shown. By this method the relative positions of the sun, the earth, and the moon, and the conditions which result in eclipses may be illustrated.

The student is recommended to make the plots on a very much larger scale than is possible within the limits of this page; and to assist him in his work convenient dimensions are given.

THE EARTH'S ORBIT.

Fig. 1. The surface of the drawing paper represents the plane of the ecliptic; and since the difference between the lengths of the major and minor axes of the earth's orbit is inappreciable in a drawing of these dimensions, it may be represented by an eccentric circle. The axis is drawn through the sun to the longitude of perihelion (=101°.6).

Representing ten million miles by a half inch, the radius of the circle, or mean distance from the sun to the earth, is 4.645 inches. The



eccentricity e is one sixtieth part of the semi-major axis (=0.0167). From this distance from the sun as a centre the earth's orbit is described.

Mercury's Orbit.

Since the planet's orbit is inclined to the plane of the ecliptic, its projection on that plane is not shown in its true form. But the difference between the projection and the true form is scarcely appreciable in the accompanying drawing. The trace of the plane of the orbit is the line of nodes NN', which is drawn through the sun to the longitude of the node ($=47°.4$). The full line shows that part of the orbit which is above the ecliptic; the dotted line the part below. Looking at the orbit and the ecliptic in the direction of the arrow A we have an edge view showing the inclination of the orbit to the ecliptic ($=7°$). This view shows the small difference between the true dimensions and the projection. The projection of a line on a plane is equal to its length multiplied by the cosine of the angle it

forms with the plane. The cosine of $7° = 0.9925$. That is to say, the difference is less than one hundredth part of the true length of the line. The arrow heads show the limits of the projection.

The position of perihelion is on a line drawn through the sun to the longitude of perihelion ($= 76°.24$). In order to avoid confusion in the drawing, a representation of Mercury's orbit by four arcs of

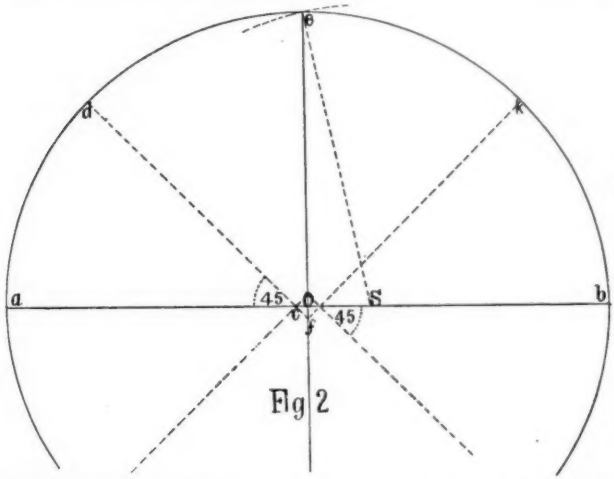


Fig 2

circles which, if the radii are carefully selected, in a drawing of these dimensions, apparently coincides with the ellipse, is shown separately on a larger scale in Fig. 2. Let *ab* be the major axis. From the centre *O* lay off *OS* equal to a little over one-fifth (=0.2056) of *Ob* to *S*, the position of the sun. From the centre *S* with a radius equal to *Oa* describe an arc intersecting the minor axis *Oe* at its vertex *e*. On each axis and on each side of the centre lay off a distance equal to one twenty-fifth ($= 0.04$) of the semi-major axis. Through these points draw lines forming angles of 45° with the axes; and from these centres on the major axis, with a radius equal to *ca*, draw arcs which pass through the vertices of the major axis; and from the centres on the minor axis, with a radius equal to *fd*, draw arcs which pass through the vertices of the minor axis. These arcs are limited by the 45° lines and have common tangents at the points *h*, *k*, etc. The length of the major axis in Fig. 1 is 3.6 inches, in which Mercury's orbit is drawn to the same scale as the earth's orbit.

Mercury's period of revolution is very nearly 88 days ($= 87^{d}.969$). This year the planet makes the perihelion passage on Feb. 2, May 1, July 28, and Oct. 24; it is at aphelion on Mar. 18, June 14, Sept. 10, and Dec. 7. It reaches the ascending node *N* on Jan. 28, Apr. 26, July 23, and Oct. 19; and the descending node *N'* on Mar. 7, June 3,

Aug. 30, and Nov. 26. The maximum heliocentric latitude is found by passing a plane through the sun perpendicular to the ecliptic, whose trace *sn* is perpendicular to NN', the trace of the plane of the planet's orbit. The points below and above the ecliptic are respectively *s* and *n*. It will be noted that the maximum *distance* of the planet above and below the ecliptic is at a point in each case where the tangent to the orbit is parallel to the trace NN'. Mercury is at *s* on Jan. 9, Apr. 7, July 4, Sept. 30, and Dec. 27; and at *n* on Feb. 12, May 11, Aug. 7, and Nov. 3.

A satisfactory way to study the relative positions of the earth and Mercury during the year is in three groups of five each in the following order:—great elongation, stationary, inferior conjunction, stationary, and great elongation. In order to avoid confusion in the drawing only one group, viz. that between Jan. 29 and Mar. 12, is fully illustrated. On Jan. 29 the planet reaches greatest elongation when it is approaching perihelion p. The angle α differs a very little from its true value because Mercury is very near the node N. This angle is small as compared with that which is subtended when the planet it at or near aphelion. On Feb. 4 Mercury is apparently stationary; on Feb. 13 it reaches inferior conjunction; and on Feb. 26 it is again stationary. On Mar. 12 it is at greatest elongation when approaching aphelion *a*, and when Mercury is at its apparent maximum distance from the sun this year. The angle β is shown very nearly in its true value because the planet is near the node N'.

On Sept. 19, Mercury is at greatest elongation, when the angle γ is seen in projection; the planet is stationary on Oct. 2; and at inferior conjunction on Oct. 14. The student may complete this group, and also that including inferior conjunction on June 17. He may also plot the positions of the earth and Mercury for superior conjunction on Apr. 24, Aug. 6, and Dec. 6.

EFFECT OF THE SUN-SPOTS ON THE TERRESTIAL TEMPERATURE.

By P. G. SEARLES*

There has been considerable speculation over the cause of the extremely hot weather experienced during the summer, but the theories advanced seem to have failed to include one which deserves consideration. There apparently has been no discussion of the possible relationship between high temperature on the earth and abnormal spots on the sun. Although sun-spots have been seen and measured for almost two centuries, no definite final reason for their existence has

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been found, hence it is impossible to dogmatize upon their effect on terrestrial temperature, but such an effect is a possibility. One of the earliest theories of sun-spots was advanced by Wilson in 1774, that they were really hollows in the photosphere, and that what was seen was perspective shadows. This idea was however soon abandoned. Then the theory was advanced that they were due to disturbances caused by meteors, etc. falling into the sun. While various bodies do fall into the sun, just as the earth is also bombarded, still it is improbable that the spots could be caused entirely by such activity. If the sun received sufficient bodies to cause the huge spots seen, the earth would also be the recipient of much larger and more numerous masses than have heretofore been observed. It is very possible however that occasionally large bodies (probably traveling alone) strike the sun, without any fragments reaching the earth, or without any direct effect being observed on the earth.

Eruptions from the interior of extremely hot gases is also given as a cause of sun-spots. This explanation is plausible as the temperautre in the interior of the sun, while not capable of being measured, is probably some thousands of degrees above the temperature of the photosphere.

Another cause may be solar atmospheric disturbances of cyclonic nature. The storm would be composed of incandescent gases moving with great velocity. In 1908 Hale proved the existence of magnetic fields in the higher levels of the spots, and concluded that these fields are due to a vortical motion of particles carrying static electric charges. Thus there would be a cyclonic motion in the upper part of the spots. St. John found that at the lower levels there is motion radially outward from the sun-spot centers; at levels about 3000 miles higher there is no horizontal motion, and at the top (15,000 miles) the motion is towards the center. This would suggest of course that the spots are produced by cooler gases from high levels rushing in towards the center, descending, and then spreading out at lower levels under the pressure of the other descending cool gases. It has been found however, that the material flowing in and down does not equal that flowing out at the lower levels. It is therefore thought possible that the spots are formed by currents ascending from the sun's interior, and spreading out just above the photosphere. The descending inrush of chromospheric material would then be a secondary result.

The spots vary in intensity and duration, and are more or less periodic. The period of maximum activity is from 6 to 15 years with an average of about 11 years. The spots usually last a month or two, although at times their life is as long as eighteen months or two years. They occur in two belts, from latitude 6 degrees to latitude 35 degrees above and below the solar equator. The individual spots drift in latitude and longitude, and often have complicated internal movements. In size the umbra (or darker central portion) reaches 50,000 miles

across, while the penumbra (or lighter outward portion) reaches a diameter of 200,000 miles. Now, what connection has all this with the earth's temperature?

First consider the effect of a meteor falling into the sun. If it fell from a distance of 93,000,000 miles (the distance of the earth from the sun), it would strike with a velocity of 380 miles, and the heat generated would be about 2300 times that produced by combustion of an equal amount of carbon and oxygen. If a meteor of sufficient size fell, a tremendous amount of heat would be generated, and the heat would continue until the meteor were consumed, that is, until it reaches the condition of the sun. A portion of this excess heat would reach the earth and cause a higher terrestrial temperature. It would hardly be probable that a large number of meteors would strike the sun, because, as mentioned above, if a large number were present in space, some would strike the earth. But one large meteor would cause a considerable temperature increase, and there is no reason for thinking that an occasional meteor of great size does not reach the sun.

But at this point the periodicity of the spots enters to make us doubt that the entire temperature increase could be due to meteor combustion alone. If the spots are caused by ascending eruptions of the hot gases from the interior of the sun, it is probable that the greater the eruption, the greater the heat at the surface, and hence the greater heat (or higher temperature) sent out through space.

When the spectra of the sun-spots is compared with the spectra of certain stars which seem to be failing through age (like Mira Ceti, which every 11 months flares up into a greater brilliancy and then sinks back into comparative obscurity) there is seen a marked resemblance. The sun therefore seems to be variable in regard to its output of energy. The entire surface of the sun is enveloped with an obscuring veil. All over the surface are dark specks so numerous that they probably cut off from 1/10 to 1/20 of the light that should be received from the sun if they were not present. Observance of other stars leads to the belief that this condition is due to a process of refrigeration which will make the sun more and more variable until it ends in extinction.

Now the variability of the sun's brilliancy would lead to a variability in the heat given off. The variability of energy output and the appearance of sun-spots are periodic, and at certain periods the maxima coincide or are opposed.

When each reaches a certain point, a larger amount of heat than normal is radiated, and of this excess heat, enough reaches the earth to cause a higher temperature. Add to this the possible effect of a huge meteor falling so as to add its heat of combustion, and it is easy to see how at certain times under favorable conditions the terrestrial temperature could be raised. This of course would apply to any or all seasons of the year, and thus if the explanation given herein is at

all correct, the coming winter should be mild with temperatures above normal.

The theory is at least supported by the two facts: that the past summer has been abnormally hot, and that the sun-spots have been abnormally large.

October 29, 1921.

HYPOTHESIS ON THE FORMATION OF NEW STARS.

By ALEXANDRE VERRONET.*

It was first thought that a new star (Nova) resulted from the *direct impact between two condensed stars.*

In that case we can easily calculate the resulting energy. It is a maximum *if the two masses are equal in size.* Assuming the same densities, without expansion, it is equal to 1.16 of the energy of formation of one of the stars. We find in this case that *the radius resulting cannot exceed double the radius of one of the primitive stars.*

The average temperature of the resulting star is less than four times the interior temperature of the primitive stars. Let us consider masses equal to the sun's mass. The central temperature, lower than 3 times the surface temperature of the nucleus, is probably around 12,000° C.

The temperature of formation of the new star would be about 48,000° C.

The increase in real magnitude would be 10.5. The variation of brightness would be only about 0.27 magnitude per year and much too weak.

For a small mass m falling upon a mass M, say about $m = 0.001\ M$, like Jupiter falling upon the sun, assuming that the impact of m has heated a superficial mass km from T_1 to T, we have within 0.1 more or less,

$$3\ km\ T = MT_1$$

If $k = 10$, the temperature is multiplied by 33, and we obtain 200,000° for a mass like the sun. The brightness increases some 18.2 magnitudes on account of the impact, but it decreases afterwards about 1 magnitude per day (0.96).

These numbers approximate the observed reality. But the probability of impact of two stars would require 10,000 times more stars to explain the frequency of new stars (H. Poincaré, *Hypothèses cosmogoniques,* pages 262 and 249). The velocity of the impact would be such that the fusion and the maximum of brightness would

*Comtes rendus de l'Academie de Science de Paris; T. 172, 1921, Page 666. Translated from the French by Aristide Corre, Member of the "Société Astronomique de France."

take place in a few minutes instead of a few days. M. Belot, recently followed by Ch. Nordmann, put forward the hypothesis of a ***condensed star hitting a nebula,*** which explains the observed facts better.

Let D be the density of the spherical nebula, R its radius, m' its mass, v the relative velocity of the two bodies due to their mutual attraction. The energy absorbed by the superficial heating becomes quickly negligible. Let T be the new superficial temperature, equating the radiated energy and the impact energy per cm²/sec, we have at the entrance into the nebula

$$\sigma T^4 = 1/8\, Dv^3,\ v^2 = 2f\,(m + m')/R.$$

A sun penetrating into a homogeneous nebula of the same mass, extending out as far as the earth, would be raised to a temperature of about 16,200°. Its brightness would be 50 times greater, an increase of 4.33 magnitudes. This brightness would reach its maximum in a few hours, which would increase but little, and so the velocity. It would last during the time of the crossing, 25 days at most, and would wane as rapidly as it rose, without leaving any lasting traces, the action being only superficial.

For an increase in brightness of 10 magnitudes, the radius of the nebula must be reduced to 0.31 of the distance earth-sun. The time of the maximum would be 4 days. For 15 magnitudes, it must be reduced to 0.10 and the time is reduced to 18 hours.

A nebula being condensed to the maximum, density in inverse ratio to the square of the distance, would give an increase of three magnitudes at the distance of the earth, 6 at 1/4 of this distance, 9 at 1/8, 15 magnitudes at 1/16, this being about 13 solar radii from the center.

A parabolic orbit, being practically a rectilineal fall, gives the same formula and the same results. The loss of velocity δv^2, with major axis of the new orbit a and time of revolution t, would be given by the formula (r being the radius of the condensed star)

$$\delta v^2/v^2 = 6r^2/R^2 = R/a = (1/2)^{1/3}(t_1/t)^{2/3}.$$

For the three radii of the nebulae considered above, the major axis would become equal to 1300, 125, and 13 radii of the orbit of the earth; the time of revolution would be about 400,000 years, 15,000 years and 400 years. The star would return and pass again through the nebula and finally whirl round and round inside of it upon spiral (curves), growing smaller and smaller and at last become agglomerated with it. The new star, according to this hypothesis, would rather correspond to *the final phase of the agglomeration of a star and a nebula, with a strong central condensation.*

But we then have to assume that the nebulae are 100 times more numerous than the stars to reconcile the frequency of the new stars with the probability indicated by Poincaré. We are then led to believe

that a new or revived star, results from the fusion of a double system, a double star whose components are very close together.

In this case we must still deduct from the energy furnished by the direct impact, the rotative energy remaining, plus the energy formerly lost by friction, to make circular orbits. The resulting energy would be reduced by only one half. We find practically the same results as in the first case. The objections as to time and probability no longer exist. A mass a little larger than Jupiter, becoming agglomerated with the sun, would have been sufficient formerly to make a beautiful new star and explain all about its present rotation.

The accessory phenomena can also be explained by the increase in temperature. The expansion gives ascending currents, whose velocity is the same as that of molecules, viz. 90 km/sec for dissociated hydrogen, at 300,000°, and a velocity 45 times larger for electrons produced by (intense) ionization. We have 1,000 kilometers for a proportion of one fourth. Descending currents are due to the rebound near the surface, with a velocity of 612 km in case of a mass of the size of the sun, and about twice as much for a mass twice as great.

The ascending currents grow cooler and slacken. They should show absorption lines, indicating a smaller velocity, directed towards the outside. The descending currents get warmer by transformation of kinetic energy. They should give bright lines, showing a greater velocity towards the interior. This is verified by spectroscopic measurements.

The pressure of radiation due to the temperature far exceeds gravitation, for fine particles like those of the corona. These will be driven away, dragging along the gaseous molecules, to form a nebulosity around the star, which has become a *star-nebula*. The velocity approaches the speed of light, and becomes practically constant at a certain distance (Nova Persei). We obtain after a year, for a new star located at 1,000 parsecs, a nebulosity of 1′ of apparent diameter, and 600,000 radii of the orbit of the earth, as its real diameter.

TWENTY-SEVENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

ABSTRACTS OF PAPERS.

(*Continued from page* 168.)

BARIUM AND LITHIUM IN THE SUN.

By H. N. Russell and K. T. Compton.

According to Saha's theory of ionization, elements of the same ionization potential should be ionized to the same degree in the sun (or in any stellar atmosphere), and the relative strength of their ordi-

nary and enhanced lines should be the same. Sodium and barium, however, have the same ionization potential, yet the lines of the neutral sodium atom are strong in the sun, while those of the neutral atom of barium are excessively faint, if present at all, although its enhanced lines are strong. This indicates that the actual degree of ionization in the sun is much greater for barium than for sodium.

It is certain, however, that atoms in the reversing layer may acquire internal energy by absorption of radiation from the photosphere, as well as by the processes depending on the temperature of the medium, which alone are considered by Saha. In the case of barium, the strength of its principal enhanced lines shows that many of the ionized atoms have a second electron partly removed by absorption of radiation. This may well render them temporarily incapable of a return to the neutral state. Meanwhile, any neutral atoms which may be formed are exposed to the full solar radiation, which, when absorbed, tends to return them to the ionized conditions.

For sodium both these factors are absent. The enhanced lines lie in the extreme ultra-violet, where the sun probably radiates very little energy. As for the neutral atoms, those in the reversing layer must be largely shielded against the particular wave-lengths which affect them—the D lines—by the heavy absorption in the lower layers, which is evidenced by the winged character of these lines.

Hence the influence of radiation in maintaining the atoms in an ionized state is much more powerful for barium than for sodium, and the observed difference may be explained.

Lithium and rubidium afford a similar instance. Both appear to be completely ionized in the sun, and the lines of the neutral atoms of both are faintly visible in the spot spectrum—ionization being diminished at the lower temperature. But lithium has the higher ionization potential of the two, and should be much less ionized.

It is possible that the low atomic weight of lithium may have something to do with this. Its lines would be much more widened by the Doppler effect due to the thermal agitation of the atoms, and thus enabled to absorb solar radiation over a greater range of wave-lengths. This would tend to facilitate the ionization of lithium more than rubidium, and may help to explain the difficulty.

INCREASED IONIZATION OVER SOLAR FACULAE.

By Charles E. St. John.

On the Bohr theory radiation of the normal or arc-type occurs when the nuclear charge is unity and an electron falls from an orbit to one of lower potential energy. The enhanced or spark lines are produced when the nucleus is doubly charged and the atom is first-step ionized. Saha has adapted the Nernst equation for the equilibrium of gaseous reactions to the determination of the percentage of ionized to un-

ionized atoms as a function of temperatures and pressure. The Saha equation suggests, as he points out, that in the spectra of faculae, owing to higher temperature, the percentage of ionization should be increased and hence the enhanced lines strengthened. Preliminary spectrograms of faculae show changes in the intensity of the enhanced lines in agreement with this deduction, the spectrum changing from G0 to F-type, that is in the direction of higher temperature. The preliminary results for titanium are as follows:

Wave-Length	Class of Line	Effect over Faculae
4306.078	Arc	No change
4443.976	Spark	Strengthened
4468.663	Spark	Strengthened
4501.445	Spark	Strengthened
4548.198	Arc	No change
4527.490	Arc	No change
4572.156	Spark	Strengthened.

THE SPECTRUM OF VENUS; NO OXYGEN OR WATER-VAPOR LINES PRESENT.

By Charles E. St. John and Seth B. Nicholson.

The literature on planetary atmospheres is permeated with the assumption that the atmosphere of Venus is similar to our own, in particular as to the presence of oxygen and water vapor. This assumption rests upon spectrographic observations with low dispersion in which an increased intensity of the terrestrial lines was thought to be seen in spectra of Venus. Spectrograms of Venus with a dispersion of 3 A per mm when the relative velocity was sufficient to separate lines due to atmospheric absorption in Venus from the corresponding terrestrial lines show, however, no trace of lines in the positions in which the Venus components should appear. From comparison with laboratory observations it is deduced that companions to the terrestrial lines should have been detected, if the light had penetrated a layer of oxygen on Venus equivalent in radial depth to 3 meters of oxygen under normal conditions.

In the depth penetrated in the planet's atmosphere there was then less than one five-hundredth part of the amount of oxygen in the earth's atmosphere.

As to water vapor, it is deduced that if the solar beam had traversed in and out, one millimeter of precipitable water, the water vapor lines would have been doubled.

According to Jewell's observations the water vapor in the atmosphere over Baltimore is equivalent to 40 mm of water. Moore gives it as about 50 mm for the ordinary American climate.

A COMPARISON OF STAR POSITIONS DERIVED WITH THE DOUBLET WITH THE P. G. C.

By Frank Schlesinger.

There are 188 stars in the P. G. C. that are also in the Photographic Zone Catalog from $+2°$ to $-2°$ declination, compiled by means of a doublet. Their mean magnitude is 6.2, which is more than two magnitudes brighter than the average of the stars in the Zone Catalog. The probable error of one difference between the two positions comes out $\pm''.030$ in right ascension and $\pm''.029$ in declination. If we divide the stars into two halves according to their magnitudes, the mean magnitude for the brighter half is 5.5 and the probable errors of one difference from the P. G. C. are $\pm''.029$ and $\pm''.028$. The average magnitude for the fainter half is 7.0 and the probable errors are $\pm''.031$ and $\pm''.030$. The conclusion is that stars at least as bright as the fifth magnitude may be used as comparison stars on plates taken with this doublet, in order to derive the places of ninth magnitude stars without much decrease in accuracy as compared with comparison stars of the eighth or ninth magnitude. This conclusion has an important bearing on work that is contemplated at the Yale Observatory on the repetition of the A. G. Catalog by means of photography.

REPORT OF STELLAR INVESTIGATIONS.

By Harlow Shapley.

A series of twenty slides was exhibited to illustrate various phases of the work now being carried on at Harvard. Among the subjects discussed were the following:

1. Objective-prism photographs of the brighter stars of Classes G, K, and M are being used for the determination of luminosity and distance. The parallaxes of fifty stars of Class K have been derived by Dr. Lindblad and the writer. The accuracy is apparently of the same order as that obtained by the Mount Wilson observers using slit spectrograms made with the 60-inch and 100-inch reflectors. In this work emphasis is placed on the southern stars, few of which have ever been observed for parallax.

2. The variable star, 224937, discovered by Miss Ashall and discussed by Miss Leavitt in *Harvard Circular* 207, is of particular interest because of its very short period, 3.9 hours between successive maxima. Mr. Campbell has observed the star extensively with the polarizing photometer, finding alternate minima of different depths. The star is apparently an ellipsoidal eclipsing binary of spectral class G, with high mean density.

3. A discussion by Miss Cannon and the writer of the distribution of Class A stars of the *Henry Draper Catalogue* shows a trace of the secondary galaxy. Deviation of the brighter stars of this class from

the galactic circle is less conspicuous than for the B stars. The faint A stars show no clear affiliation with the local system.

4. The light-curve of the star S Apodis, *145970*, derived by Mr. Campbell from the observations contributed by observers in the southern hemisphere, indicates that the star belongs to the uncommon and peculiar class of variables represented by R Coronae Borealis.

5. The mirrors and mounting of a 60-inch reflecting telescope, purchased nearly twenty years ago by the Harvard Observatory from the estate of A. A. Common, have been tested and found to be satisfactory for stellar investigations. It is hoped to put the instrument in operation within a year.

FOUR ECLIPSING VARIABLES OBSERVED BY HOFFMEISTER.

By Bancroft Walker Sitterly.

The variables RW Leonis, WY Persei, RS Serpentis, and SS Bootis were observed by Herr Hoffmeister by Argelander's method, and his results appear in *Astronomische Nachrichten*, Nos. 4985 and 5113. The observations, while determining the period and the general nature of the variation in each case excellently, are not sufficiently precise to give unique elements, but it is possible to find limits between which the true solution lies, and to gain an idea of the degree of precision obtainable, for each system.

RW Leonis has a period of 1.7 days and a primary minimum of depth 1.4 magnitudes, but no sensible secondary. The limiting solutions, assuming completely darkening disks, are given below. Star *p* is in front at primary minimum, while star *s* is in front at secondary minimum.

	Solution A		Solution B	
	Star *p*	Star *s*	Star *p*	Star *s*
Light	0.03	0.97	0.08	0.92
Radius	0.17	0.22	0.22	0.15
Density	0.19	0.35	0.09	1.1
Inclination	90°		82°	
Eclipse	annular		partial	

WY Persei has a period of 3.3 days and a primary minimum 2.7 magnitudes deep, but no sensible secondary. The curve is not so evenly observed as that of RW Leonis, the beginning and end of the eclipse being entirely neglected, but the shape of the lower part is such that the elements are determined with considerable precision. The best "darkened" solution is:

	Star *p*	Star *s*
Light	0.03	0.97
Radius	0.26	0.26
Density	0.014	0.054
Inclination	88°	
Eclipse	partial	

RS Serpentis is of the β-Lyrae type, the two stars very close to one

another and clearly elliptical in figure. The period is short, less than 14½ hours. The minima are of nearly equal depth, the lowest point observed at primary being 0.7 magnitude below maximum, at secondary, 0.6. In general, a curve with such shallow minima will not give a unique solution even if accurately observed. But in this case the minima are both deep enough to be separately solved and wide at the bottom, and the secondary seems a little steeper than the other, proving, if the difference is real, that the stars are darkened toward the limb, and that the larger star is eclipsed nearly or quite annularly by the smaller at primary. The elements best fitting this supposition are:

	Star *p*	Star *s*
Light	0.40	0.60
Major axis	0.34	0.40
Minor axis	0.31	0.36
Density	0.46	0.44
Inclination	87°	
Eclipse	annular	

If the eclipse curves are treated as similar in form, a considerable range of solutions is possible, all giving almost identical curves.

SS Bootis, with a period of 7.6 days, has a primary minimum 0.4 magnitude deep and a clearly perceptible secondary whose depth is very near to 0.06 magnitude. The observations, like those of WY Persei, neglect the neighborhood of the beginning and end of the eclipse, but are otherwise fairly consistent; the curve is excellent, considering that it was obtained by estimation, but the elements are practically indeterminate. A "uniform" solution, assuming that at primary a large star totally eclipses a slightly fainter small one, gives a well-fitting curve; so does the opposite assumption that a small faint star eclipses annularly a large and much brighter one; so does every degree of gradation between these limits. The two extremes and one intermediate solution are given:

	Solution A		Solution B		Solution C	
	Star *p*	Star *s*	Star *p*	Star *s*	Star *p*	Star *s*
Light	0.64	0.36	0.12	0.88	0.05	0.95
Radius	0.22	0.06	0.14	0.14	0.09	0.15
Density	0.014	0.43	0.023	0.054	0.058	0.056
Inclination	81°		82°		90°	
Eclipse	total		partial		annular	

It was considered superfluous to try "darkened" solutions.

These results emphasize the necessity of the utmost precision, to the hundredth of a magnitude, in observation of eclipsing variables, if really definite elements are to be obtained, and the necessity also of distributing the measures evenly over every part of the curve, with special attention to the secondary, and to the neighborhood of beginning and end of the eclipse. RS Serpentis would repay an intensive study, but since its maximum magnitude is 11, its period 0.6 day, and its position 13° south of the equator, a good instrument would be required.

DIFFERENTIAL REFRACTION ON ASTRONOMICAL PHOTOGRAPHS.

By Frederick Slocum.

To illustrate the effects of differential refraction, eleven photographs of the Pleiades were taken ranging from 5 hours east up to the meridian.

The meridian plate, No. 190, was used as a standard and all the others compared with it by the linear equations

$$ax + by + c = x_0 - x$$
$$dx + ey + f = y_0 - y$$

where a and e are the scale coefficients in the x and y directions respectively. Twelve stars of nearly the same magnitude and symmetrically distributed were measured on each plate.

The folowing table shows the change in scale value in the x and y directions and the mean errors for a single star equation on each plate.

Plate	Hour Angle	Altitude	a coefficient	e coefficient	$\pm e_x$	e_y
	h	°	mm	mm	"	"
180	5.1	25	+.0007177	+.0003285	±0.104	±0.102
1	4.6	31	+ 4689	+ 2147	.201	.261
2	4.0	38	+ 1899	+ 88	.200	.120
3	3.5	43	+ 1074	+ 157	.147	.191
4	3.1	48	+ 1281	+ 48	.155	.127
5	2.6	51	+ 150	+ 94	.157	.097
6	2.1	58	+ 3	+ 25	.167	.108
7	1.6	63	— 35	+ 62	.160	.126
8	1.1	67	— 96	+ 9	.191	.071
9	.6	70	— 4	+ 89	.178	.105
190	.2	72				

The effect of refraction, free from the smoothing out due to the least squares solutions, was clearly shown by the measured distances of two stars lying nearly along the x-axis, and the distances of a pair of stars along the y-axis.

For comparison with these effects the differential refraction was computed for different hour angles for stars located in various parts of the plate.

The effect of differential refraction upon the displacement of stars on eclipse plates was discussed and the conclusion reached that no appreciable amount of that displacement could be due to residual refraction.

NOTES ON VARIABLE STARS.

By Joel Stebbins.

ζ Andromedae (1900 R. A. $0^h\,42^m$ Decl. $+23°\,43'$, magnitude 4.30, spectrum K) is either an eclipsing or an ellipsoidal variable with a range of about a tenth of a magnitude in the spectroscopic period of

17.77 days. A thorough study of this system will be made, as it is seldom that light variation can be detected in a spectroscopic binary with a K spectrum.

Algol was observed for times of minimum in 1919, 1920, and 1921, and there were noted certain variations from a constant period. In the discussion at the meeting it was pointed out by Dr. Schlesinger that the discrepancies were of the right order to be accounted for by the third body with a period of nearly two years. On checking up with the published orbits, it is found that the photometric observations do not agree with the period of 1.899 years adopted by Curtiss, but they confirm the alternative period of 1.624 years which he rejected (*Astrophysical Journal*, **28**, 156, 1908.) With this latter period and the corresponding elements, the reduction of the times to the center of the orbit of the triple system is given by:

$$\text{Reduction to center} = +0.^{d}00315 \sin 0.^{\circ}6069\ (t - \text{J. D. } 2415933)$$

In the following table the first column gives the observed normal dates of heliocentric minima of Algol, the second column gives the corrections from the above formula, while the residuals in the last column are based upon an epoch and period of the eclipsing system which satisfy exactly the first and third minima after applying the reductions to center.

Observed Minimum	Reduction to center	O. — C.
	d	d
J. D. 2422321.5947	—0.0031	0.0000
2619.7866	+0.0031	—0.0012
2986.8075	—0.0020	0.0000

With Curtiss' period of 1.899 years and the corresponding elements, the similar residual for the second normal is —0.0070 day, or nearly six times as large as for the shorter period. Schlesinger has also published a period of 1.874 years (*Publications Astronomical and Astrophysical Society of America*, **2**, 128, 1912), but as he is continuing the study of the triple system a revised set of spectroscopic elements will soon be forthcoming. As the matter stands, the photometric results point to the period of 1.624 years for the third body.

THE PROPER-MOTIONS OF 154 RED STARS.

By Ralph E. Wilson.

This paper contains the proper-motions of 154 stars of Classes Md, R, N, Mc variables and a few, the spectra of which are peculiar or as yet unclassified. Thirty-eight of them have been taken from Boss's *Preliminary General Catalogue*, Norlund's list in the *Publications of the Copenhagen Observatory*, and a list by Misses Young and Farns-

worth, *Astronomical Journal*, **33**, 194, 1921, sufficient material not being available to justify new determinations. The remaining 116 are new proper-motions derived by the writer following the system of the *Preliminary General Catalogue*. In the computations for the southern stars were included the unpublished results of the San Luis observations of 1909-10.

Only three of the stars, o Ceti, Md, L_2 Puppis, Md, and R Orionis, Pec., R?, have proper-motions exceeding 20″ per century. The Class N stars appear to have systematically small proper-motions, the four determinations exceeding 6″ per century being of low weight. The mean proper-motions of the different classes are

Class	μ	Number	Weight
Mc, Md	0″.0559	80	89.7
R	.0477	13	11.5
N	.0266	46	57.8
Unclassified	.0385	15	15.9

A solution for the coördinates of the solar motion referred to this list of stars gives

$$A = 269°.8 \qquad D = +35°.2 \qquad M = 0″.0153$$

The parallactic motion M derived from the Md stars is 0″.0190. The coördination of this value with the solar speed derived from the line-of-sight observations of these stars, $V = 36.5$ km per second, indicates a mean parallax for stars of this class of 0″.0025.

A solution for the stream motion of these stars indicates preferential motion in the direction $A_1 = 82°.2$, $D_1 = +18°.3$, the mean-square motions along the axes of the velocity ellipsoid being 16.06, 9.30 and 7.89. Owing to the approximate equality of the velocities along the two minor axes, the directions of these axes in the plane perpendicular to the direction of preferential motion are not well determined.

PLANET NOTES FOR MAY.

(The times given are in Central Standard Time.)

The phases of the *moon* will occur as follows:

		d	h	m	
First quarter	May	4	6	55.8	A. M.
Full moon		11	0	6.2	A. M.
Last quarter		18	12	16.9	P. M.
New moon		26	12	4.0	P. M.

Mercury will be in Taurus practically the entire month. The planet will be in perihelion May 1 at 10 A. M. and at greatest eastern elongation on the 23rd at 1 P. M. At this elongation it will be nearly 23° from the sun and therefore easily seen after sunset.

Venus will be about 5° from the Pleiades on the 1st and near ϵ Geminorum on the 31st. The planet will be a conspicuous object in the western sky after sunset.

Mars will be in the southern part of Ophiuchus throughout the month. The planet reaches the eastern part of its curve in this constellation on the 7th at 9 P. M. and then starts moving westward. Its apparent diameter increases from 14″.8 on the 1st to 19″.4 on the 31st. Meridian transit occurs about 3 A. M. at the beginning of the month and about $12^h\ 48^m$ A. M. at the close.

Jupiter and *Saturn* will both be in Virgo this month and in good position for early evening observation. The former will be on the meridian about 9 P. M. and the latter about 8:30 P. M. on the 15th. The interesting satellite phenomena will be found on another page.

Uranus will be in Aquarius and in position for observation only a short time before dawn. Its position on the 15th will be R. A. $= 22^h\ 58^m\ 59^s$; Dec. $-7°\ 19'\ 57''$.

Neptune will be in quadrature on the 4th at 5 A. M. and four hours later it will be in conjunction with the moon, with the planet 4° 21′ north of the moon's center.

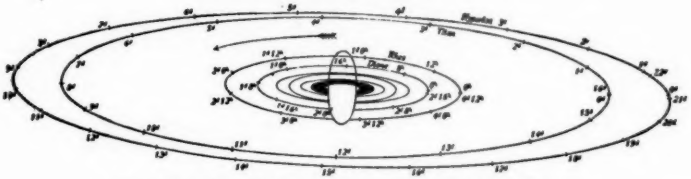
Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.
[From the *American Ephemeris.*]
CENTRAL STANDARD TIME. NOON = 0^h

1922		h	m			1922		h	m		
May	1	8	45	III	Oc. D.	May	12	6	43	I	Tr. E.
		10	55	III	Oc. R.			7	32	III	Sh. E.
		11	15	III	Ec. D.			7	32	I	Sh. E.
		13	33	III	Ec. R.		13	8	02	II	Oc. D.
		13	51	I	Tr. I.			12	21	II	Ec. R.
		14	29	I	Sh. I.		17	11	52	I	Tr. I.
		16	02	I	Tr. E.			12	47	I	Sh. I.
		16	41	I	Sh. E.		18	8	59	I	Oc. D.
	2	10	59	I	Oc. D.			12	07	I	Ec. R.
		13	50	I	Ec. R.		19	7	16	I	Sh. I.
		16	31	II	Oc. D.			7	42	III	Tr. E.
	3	8	17	I	Tr. I.			8	31	I	Tr. E.
		8	57	I	Sh. I.			9	16	III	Sh. I.
		10	29	I	Tr. E.			9	27	I	Sh. E.
		11	09	I	Sh. E.			11	30	III	Sh. E.
	4	8	18	I	Ec. R.		20	10	25	II	Oc. D.
		10	45	II	Tr. I.		22	7	09	II	Tr. E.
		12	07	II	Sh. I.			9	06	II	Sh. E.
		13	17	II	Tr. E.		25	10	48	I	Oc. D.
		14	39	II	Sh. E.		26	8	08	I	Tr. I.
	6	9	45	II	Ec. R.			8	59	III	Tr. I.
	8	12	08	III	Oc. D.			9	11	I	Sh. I.
		14	21	III	Oc. R.			10	20	I	Tr. E.
	9	12	45	I	Oc. D.			11	19	III	Tr. E.
	10	10	04	I	Tr. I.			11	22	I	Sh. E.
		10	52	I	Sh. I.		27	8	30	I	Ec. R.
		12	16	I	Tr. E.			7	00	II	Tr. I.
		13	04	I	Sh. E.			9	10	II	Sh. I.
	11	7	12	I	Oc. D.			9	34	II	Tr. E.
		10	13	I	Ec. R.			11	41	II	Sh. E.
		13	04	II	Tr. I.						

NOTE:—I. denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Saturn's Satellites.



Greatest elongations visible in the United States.
[From the *American Ephemeris.*]

CENTRAL STANDARD TIME. NOON = 0^h

I. Mimas. Period 0^d $22^h.6$.

1922	d	h		d	h		d	h		d	h	
May	1	7.9	W	May 8	9.5	E	May 16	9.8	W	May 24	10.1	E
	2	6.5	W	9	8.2	E	17	8.4	W	25	8.7	E
	3	16.5	E	10	6.8	E	18	7.0	W	26	7.3	E
	4	15.1	E	12	15.3	E	20	15.6	E	29	14.5	W
	5	13.7	E	13	13.9	E	21	14.2	E	30	13.1	W
	6	12.3	E	14	12.6	E	22	12.6	E	31	11.7	W
	7	10.9	E	15	11.2	E	23	11.4	E			

II. Enceladus. Period 1^d $8^h.9$.

May	2	0.6	E	May 8	21.0	E	May 17	2.3	E	May 23	22.7	E
	3	9.5	E	10	5.9	E	18	11.2	E	25	7.6	E
	4	18.4	E	11	14.8	E	19	20.1	E	26	16.5	E
	6	3.2	E	12	23.6	E	21	5.0	E	28	1.4	E
	7	12.1	E	14	8.5	E	22	13.8	E	29	10.3	E
				15	17.4	E				30	19.2	E

III. Tethys. Period 1^d $21^h.3$.

May	1	13.5	E	May 9	2.7	E	May 16	15.9	E	May 24	5.2	E
	3	10.8	E	11	0.0	E	18	13.2	E	26	2.5	E
	5	8.1	E	12	21.3	E	20	10.5	E	27	23.8	E
	7	5.4	E	14	18.6	E	22	7.8	E	29	21.1	E
										31	18.4	E

IV. Dione. Period 2^d $17^h.7$.

May	1	9.9	E	May 9	14.9	E	May 17	20.0	E	May 26	1.0	E
	4	3.6	E	12	8.6	E	20	13.6	E	28	18.7	E
	6	21.3	E	15	2.3	E	23	7.3	E	31	12.4	E

V. Rhea. Period 4^d $12^h.5$.

May	1	0.5	E	May 10	1.3	E	May 19	2.0	E	May 28	2.9	E
	5	12.9	E	14	13.6	E	23	14.4	E			

VI. Titan. Period 15^d $23^h.3$.

Apr.	30	19.6	W	May 8	21.3	E	May 16	17.7	W	May 24	19.6	E

VII. Hyperion. Period 21^d $7^h.6$.

Apr.	30	2.5	E	May 9	6.3	W	May 21	5.6	E	May 30	9.6	W

VIII. Iapetus. Period 79^d $22^h.1$.

Apr.	12	7.4	E	May 1	3.4	I	May 20	2.7	W	June 9	15.6	S

IX. Phoebe. Period 523^d $15^h.6$.

		α Ph.—α Sat. m	s	δ Ph.—δ Sat. ′	″			α Ph.—α Sat. m	s	δ Ph.—δ Sat. ′	″
May	1	−2	03.0	+14	53	May	17	−1	48.9	+12	59
	3	−2	01.4	+14	40		19	−1	47.0	+12	43
	5	−1	59.7	+14	26		21	−1	45.0	+12	27
	7	−1	58.0	+14	13		23	−1	42.9	+12	11
	9	−1	56.3	+13	59		25	−1	40.8	+11	54
	11	−1	54.5	+13	44		27	−1	38.7	+11	37
	13	−1	52.7	+13	29		29	−1	36.5	+11	20
	15	−1	50.8	+13	14		31	−1	34.3	+11	03

NOTE:—E, Eastern Elongation; I, Inferior Conjunction (south of planet); W, Western Elongation; S, Superior Conjunction (north of planet).

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1922	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
May 3	84 B. Cancri	6.4	8 10	152	9 04	247	0 53
4	*h* Leonis	5.2	9 21	160	10 08	245	0 47
5	43 Leonis	6.3	5 42	101	6 59	307	1 17
6	79 Leonis	5.5	9 14	112	10 30	300	1 16
10	o Librae	6.2	14 58	72	16 01	306	1 02

VARIABLE STARS.

Two Irregular Variables of Class K.—For periodic variable stars, Class K is an uncommon spectral type. Eclipsing stars are preferably of Classes B and A; long period variables, Class Md; typical Cepheids, Classes F to G5, and cluster-type Cepheids, Classes B to F.

Mr. Maynard F. Jordan, who is making a photometric study on Harvard photographs of the variable stars of Class K, reports as follows concerning two stars for which the variability was discovered at Harvard by Miss Applegate and announced in H. C. 221:

084934,——Pyxidis; R. A. $8^h\ 49^m4$, Dec. −34 26′ (1900). The spectrum is K2. An examination of 110 photographs taken in the interval from 1899 to 1920 indicates irregular variation between the magnitude limits 8.4 and 11.0.

225134,——Lacertae; R. A. $22^h\ 51^m3$, Dec. +34 40′ (1900). The spectrum is K2. An examination of 150 photographs taken in the interval from 1898 to 1921 indicates irregular variation between the magnitude limits 9.4 and 10.2.

Harvard College Observatory Bulletin 765.

W Ursae Majoris.—With a polarizing photometer on the 12-inch polar telescope, Mr. Campbell has observed a complete minimum of the short period eclipsing binary W Ursae Majoris, 093656, at J. D. 2423094.566, heliocentric Greenwich Mean Time, indicating a correction of $-0^d.019$ to the ephemeris computed from the elements given by Shapley and van der Bilt (M. W. Contr. 140, 1917), and thus confirming the suspected variation in the period. The correction to the ephemeris computed from the elements derived by Russell, Fowler, and Borton (Ap. J. **45**, 320, 1917) is $-0^d.018$.

The changing period is of special interest since the variable is one of the few dwarf eclipsing stars on record, its period of revolution is only eight hours, its components are ellipsoidal, and its mean density, 2.45 times that of the sun, is the highest yet measured for a star.

Harvard College Observatory Bulletin 765.

New Cluster Type Variable in Small Magellanic Cloud.—A number of stars in the Small Magellanic Cloud were suspected of variation by Miss Leavitt, but not confirmed on the plates examined, and therefore not announced in Harvard Annals **60**, 4. One of the faintest of these suspected variables, with coördinates $X = 14809''$, $Y = 8606''$ (in the system employed by Miss Leavitt), has been found by the writer to be a cluster type variable with a period of approximately six-tenths of a day. The observed range is from 15.8 to 16.6. The star's designation is H. V. 3610.

Harvard College Observatory Bulletin 765.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1922 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8								
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	7 14	15 6	22 22	30 14				
UU Androm	38.5	+30 24	10.7—11.9	1 11.7	4 6	11 17	19 3	26 14				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	6 16	14 3	21 15	29 2				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	5 4	11 6	23 12	29 15				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	7 23	15 2	22 6	29 9				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 2	10 23	24 17	31 13				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 2	13 6	20 10	27 14				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 23	12 18	21 13	30 7				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6		8 4	16 3	24 1				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6				23 15				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	1 1	9 16	18 6	26 20				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	1 13	15 3	21 22	28 17				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	7 21	15 19	23 16	31 14				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	7 0	15 8	23 15	31 22				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	1 12	9 10	17 7	25 5				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8		10 20		24 1				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6		10 10	19 20	29 7				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	1 14	14 0		26 11				
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	2 9	9 1	22 9	29 1				
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	4 13	12 18	20 22	29 3				
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	1 12	13 13	19 13	25 14				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	6 19	15 11	24 3					
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	2 4	12 13	22 23					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	7 9	15 9	23 9	31 10				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1 21	7 15	19 2	30 13				
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	2 10	13 15	24 19	30 10				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	3 12	11 17	19 22	28 3				
RW Monoc	29.3	+ 8 54	9.0—10.8	1 21.7	2 18	10 9	18 0	25 15				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	7 23		20 4					
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	3 18	10 22	18 2	25 6				
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	5 5	12 1	18 20	25 16				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	2 2	11 10	20 17	30 0				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6 22	13 12	20 3	26 18				
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2		8 5	16 15	25 0				
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	6 17	13 3	19 14	26 0				
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	5 20	13 2	20 9	27 15				
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	6 12	14 14	22 17	30 20				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6		10 2	19 13	29 1				
RX Hydræ	9 00 8	— 7 52	9.1—10.5	2 06.8	5 11	12 7	19 3	25 23				
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	4 20	10 18	22 15	28 13				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5 4	11 22	18 16	25 9				
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	2 21	9 7	24 3	31 13				
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	3 5	9 19	23 0	29 14				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2		8 10	17 5	26 0				
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	4 3	11 11	18 19	26 3				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	5 8	12 3	18 22	25 16				
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	5 9	12 21	20 9	27 21				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1		10 8	19 22	29 12				
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	7 3	14 14	22 1	29 11				
133926 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	1 16	13 6	24 20	30 15				

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1922 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	3 23		10 21		24 15		31 12	
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	1 0		7 22		21 17		28 15	
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3			8 15		17 1		25 11	
SS Librae	15 43.4	—15 14	9.3—11.5	0 18.4	1 4		8 20		24 3		31 19	
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	7 15		14 23		22 7		29 15	
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	7 1		15 7		23 14		31 20	
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	1 8		10 4		19 1		27 21	
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1					21 15			
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	7 2		13 21		20 16		27 11	
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	2 20		11 5		19 15		27 23	
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	4 16		10 20		23 3		29 7	
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 16		10 20		23 5		29 9	
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3 20		11 5		18 14		25 23	
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	7 21				16 1		24 6	
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	1 9		8 22		24 0		31 13	
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	2 0		9 18		17 12		25 6	
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	1 2		9 1		17 1		25 1	
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	1 0		9 13		18 1		26 13	
WY Sagittarii	17 54.9	—23 01	9.5—10.6	4 16.0	3 19		13 3		22 11		31 19	
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	5 13		15 21				26 6	
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	5 22		13 4		20 10		27 16	
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	6 4		13 2		19 23		26 21	
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	5 7				20 10			
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 13		7 17		23 1		30 4	
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	6 23		14 2		21 5		28 8	
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	7 6		15 13				23 21	
RR Draconis	40.8	+62 34	9.3—13	2 19.9	9 6		17 18				26 6	
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	2 9		9 1		15 16		28 23	
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8	5 9		18 6				31 4	
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	3 18		11 9		19 1		26 16	
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	3 4		10 17		18 7		25 21	
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	5 3		12 8		19 12		26 17	
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	1 4		10 3		19 2		28 1	
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	6 17		13 11		20 5		26 23	
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 4		10 13		17 22		25 7	
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	3 5		8 11		18 22		29 10	
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	4 16		17 17		24 5		30 18	
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	4 21		10 21		16 21		28 21	
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	7 3		13 18		20 9		27 1	
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	4 9		13 12		22 16			
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	2 4		10 15		19 1		27 12	
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	3 4		9 23		23 12		30 7	
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 9		14 7		21 4		28 2	
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0								
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	2 8		11 23		21 14		31 4	
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	7 20				17 1		26 6	
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	3 18		11 6		18 17		26 5	
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 8		8 22		16 12		24 3	
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	1 4		11 6		21 9		31 11	
VVCygni	21 02.3	+45 23	12.1—13.8	1 11.4	3 19		11 4		18 13		25 23	
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	1 21		11 14		21 6		30 23	
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	3 22		11 18		19 15		27 12	
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	3 5		13 8		23 12			
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3					19 2			
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	3 15		8 19		19 4		29 13	
8.1914 Pegasi	51.7	+32 41	10.0—10.6	5 06.4	3 7		13 20		24 9		29 15	
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	4 20		13 3		21 10		29 17	
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	4 11		11 23		19 12		27 1	
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	1 16		9 22		18 4		26 10	

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	3 0							
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 01.7	3 0	11 3	19 6	27 10				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	8 5	15 23	23 17	31 10				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		14 17		29 12				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	4 21	12 20	20 19	28 17				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 4	9 23	17 19	25 14				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	7 12	14 19	22 2	29 9				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		10		26				
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	7 8	15 22	24 11					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1		8 22	20 1	31 4				
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0		11 23	23 14					
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	8 11	16 3	23 19	31 11				
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3		10 17	20 22	31 0				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.5	3 2	10 19	18 12	26 5				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 5	15 6	26 8	31 20				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	2 18	10 7	17 21	25 11				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			18 18					
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	8 2	15 13	23 0	30 11				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	3 16	10 21	18 2	25 7				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	2 4	10 2	17 24	25 22				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	5 14	15 17	25 21					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		12 12						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	4 21	12 20	20 19	28 17				
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	6 10	13 3	19 19	26 12				
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	3 12	12 19	22 1	31 8				
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	2 18	11 12	20 5	28 23				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0			19					
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	2 20	16 10	23 4	29 23				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2 13	15 18	22 8	28 23				
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8	4 16	14 8		24 0				
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	7 18	15 18	23 17	31 17				
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	6 0	12 18	19 11	26 5				
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	1 8	13 0	24 16	30 11				
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	2 23	12 8	21 17	31 2				
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5			16 19					
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	1 5	9 10	17 14	25 19				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	1 6	15 7	22 7	29 8				
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	1 20	10 1	18 6	26 11				
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	3 13	14 12	20 0	31 0				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 22	10 11	18 0	25 13				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 2	13 12	20 22	28 8				
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	1 7	14 21	21 15	28 10				
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	5 5	11 13	24 4	30 12				
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	7 13		17 7	27 1				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6		8 5	17 1	25 19				
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	4 17	10 18	22 21	28 23				
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	6 17	13 17	20 17	27 18				
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9								
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	5 5	12 19	20 9	27 23				
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	1 19	7 14	19 3	30 16				
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	2 2	8 20	22 8	29 2				
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	2 8	12 16		23 0				
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	5 0	11 1	23 2	29 3				
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	5 13	11 16	17 20	30 2				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1922 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	2 4	14 1	20 0	31 21				
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2		9 12	18 14	27 16				
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	3 14	17 15	24 16	31 17				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	2 15	16 15	23 15	30 15				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	2 19	10 18	18 18	26 17				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	3 11	11 4	18 21	26 13				
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	5 13	12 17	19 21	27 2				
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	6 17	15 2	23 11	31 20				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	1 11	7 18	20 10	26 17				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		9 7		25 17				
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 18	11 15	20 12	29 9				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	5 15	12 9	19 2	25 20				
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	6 19	13 13	20 6	26 23				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		8 16		23 9				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	2 1	9 22	17 18	25 15				
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	4 11	11 8	18 6	25 3				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 15	15 9	25 2	29 23				
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	3 5	11 21	20 12	29 4				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	5 14	10 23	21 16	27 1				
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1		11 12		22 9				
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	2 20	9 6	22 3	28 12				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	5 0	14 23	24 23	29 22				
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	5 13	11 0	21 21	27 8				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	3 11	8 22	19 20	30 16				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 2	7 9	19 23	26 6				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		8 7	20 10					
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	4 0	17 23	24 22	31 22				

Monthly Report of the American Association of Variable Star Observers, January 20, to February 20, 1922.

The recording secretary is very glad to be back on the job again, and especially to be greeted by such a splendid mid-winter report as is published this month. He has had the great pleasure of meeting many of the distinguished astronomers of Europe, and has found a genuine and wide spread interest in variables.

The Association is indebted to Dr. W. Sturgis Bigelow of Boston, Mass., for the gift of a splendid 5-in. Clark telescope equipment.

It should be noted that Miss A. H. Farnsworth publishes her first observations with this report. The complete list of observers for the month is as follows: Messrs. Ancarani "An," Bouton "B," Brocchi "Br," Miss Clough "Cg," Eaton "E," Miss Farnsworth "Fn," Ginori "Gi," Hoerl "Hj," Jewell "Je," Kanda "Kb," "Lacchini "L," Lacy "Lc," Leavenworth "Lv," Macaughy "Mc," McAteer "M," Merrill "Ml," Mrs. Morris "Ms," Mundt "Mu," Olcott "O," Peltier, "Pt," Pickering "Pi," Proctor "Pc," Reesinck "Rk," Skaggs, "Sg," Suter "Su," Vrooman "V," Waldo "Wl," Waterfield "Wf," Woglom "Wg," Yalden "Ya," and Miss Young "Y."

Howard O. Eaton, Recording Secretary.

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922.
January 0 = J. D. 2423055 February 0 = J. D. 2423086

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
001032 S SCULPTORIS—												
	3047.9	6.5	Kd,	3051.9	6.6	Kd,	3058.9	7.1	Kd,	3064.9	7.3	Kd,
	3079.5	7.5	Pt.									
001046 X ANDROMEDAE—												
	3034.6	8.3	Lv,	3055.6	10.4	Lv,	3072.6	10.7	Wf,	3077.5	10.7	V,
	3077.6	11.0	M,	3078.6	11.1	Wf,	3086.6	11.3	Wf,	3088.5	11.7	Pi,
	3088.5	11.6	E,	3090.6	11.7	B.						
001620 T CETI—												
	3056.3	6.0	L,	3074.2	5.4	L.						
001726 T ANDROMEDAE—												
	3055.6	9.6	Lv,	3060.6	9.9	Lv,	3079.5	11.5	Pt,	3085.6	<11.5	Br,
	3090.6	12.2	B.									
001755 T CASSIOPEIAE—												
	3060.3	8.9	L,	3062.4	9.2	Gi,	3074.5	8.8	Gi,	3079.5	8.1	Pt,
	3084.3	8.7	L,	3088.5	9.5	Pi,	3088.5	9.1	E,	3088.6	9.2	Ya,
	3090.6	8.2	B.									
001838 R ANDROMEDAE—												
	3071.6	7.4	Lc,	3076.6	7.8	B,	3077.6	7.2	V,	3078.6	7.3	Su,
	3079.5	7.3	Pt,	3084.5	7.6	Wl,	3086.7	7.5	Lc,	3088.5	7.9	Pi,
	3088.5	7.8	E,	3096.6	8.0	B.						
001909 S CETI—												
	3056.3	9.6	L,	3066.2	8.6	L,	3079.5	8.0	Pt.			
003179 Y CEPHEI—												
	3083.6	13.2	B,	3088.6	12.9	B.						
004047 U CASSIOPEIAE—												
	3055.6	10.7	Lv,	3060.6	10.9	Lv,	3069.6	<11.1	Hj,	3070.6	11.2	Lv,
	3071.6	<9.9	Hj,	3071.6	11.1	Lc,	3072.6	11.4	Wf,	3077.6	<11.1	Hj,
	3078.5	12.2	Y,	3078.6	11.7	Wf,	3079.5	11.8	Pt,	3081.6	<11.1	Hj,
	3084.6	<11.1	Hj,	3086.6	12.6	Wf,	3088.5	<12.4	Pi,	3090.6	12.6	B,
	3103.6	<12.3	Fn.									
004435 V ANDROMEDAE—												
	3052.6	<13.3	Lv,	3055.6	<13.5	Lv,	3070.6	<12.7	Lv.			
004533 RR ANDROMEDAE—												
	3072.6	8.8	Wf,	3077.6	8.6	V,	3078.6	8.5	Wf,	3088.6	8.5	B,
	3090.7	8.7	Wf.									
004746a RV CASSIOPEIAE—												
	3060.3	9.6	L,	3079.5	9.3	Pt,	3084.3	9.3	L.			
004958 W CASSIOPEIAE—												
	3071.6	9.0	Lc,	3074.5	8.1	Gi,	3077.5	9.4	Cg,	3078.4	9.4	Rk,
	3079.5	8.8	Pt,	3084.0	8.3	Br,	3085.6	8.8	Lc,	3088.6	8.4	Ya,
	3090.6	8.3	B,	3104.6	9.4	Cg.						
010102 Z CETI—												
	3074.6	14.1	B,	3083.5	13.5	B.						
011208 S PISCIUM—												
	3074.6	<14.1	B,	3083.6	<14.0	B.						
011272 S CASSIOPEIAE—												
	3055.6	8.4	Lv,	3072.7	8.6	Wf,	3078.4	8.7	Rk,	2078.7	9.2	Wf,
	3079.5	9.2	Pt,	3084.6	9.3	Ya,	3090.7	9.5	Wf,	3094.6	9.3	B.
011712 U PISCIUM—												
	3101.6	12.8	Pt.									
012350 RZ PERSEI—												
	3078.5	10.4	Y,	3088.5	10.0	B,	3103.5	10.2	Fn.			
012502 R PISCIUM—												
	3078.3	11.7	Rk.									
013238 RU ANDROMEDAE—												
	3072.7	11.1	Wf,	3078.7	11.0	Wf,	3079.5	10.9	Pt,	3086.7	11.0	Wf.
013338 Y ANDROMEDAE—												
	3088.6	<13.8	B.									
014958 X CASSIOPEIAE—												
	3079.5	11.1	Pt,	3088.6	10.1	B,	3103.6	10.9	Fn.			

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
015354 U PERSEI—												
	3079.6	8.3	Pt,	3090.6	7.7	B.						
021024 R ARIETIS—												
	3060.3	10.7	L,	3062.4	10.5	Gi,	3074.4	11.9	Gi,	3079.6	12.2	Pt,
	3084.3	12.3	L,	3084.6	12.4	Wl,	3088.6	12.1	B.			
021143a W ANDROMEDAE—												
	3068.5	11.0	Gi,	3072.2	11.2	Wf,	3078.7	11.4	Wf,	3088.6	12.2	B,
	3090.7	12.1	Wf.									
021403 o CETI—												
	3056.3	9.2	L,	3066.2	9.6	L,	3074.2	9.2	L,	3074.2	9.0	An,
	3079.6	9.0	Pt,	3081.5	9.2	O,	3084.2	9.0	L,	3084.2	9.0	An,
	3084.5	9.0	Ya,	3084.6	9.2	Wl,	3086.6	8.8	Br.			
021558 S PERSEI—												
	3072.6	9.1	B,	3088.6	9.4	B.						
022000 R CETI—												
	3047.9	8.3	Kd,	3051.9	8.7	Kd,	3064.9	9.8	Kd,	3073.9	10.0	Kd.
022150 R R PERSEI—												
	3078.5	9.8	Y,	3088.5	9.0	B,	3103.8	8.6	Fn.			
022813 U CETI—												
	3079.6	9.8	Pt.									
023080 RR CEPHEI—												
	3072.7<13.6		Wf,	3078.6	14.2	Wf,	3090.7<13.6		Wf.			
023133 R TRIANGULI—												
	3051.9	6.7	Kd,	3058.9	6.5	Kd,	3064.9	6.3	Kd,	3073.9	7.0	Kd,
	3079.6	6.5	Pt,	3088.6	7.0	Ya,	3090.6	7.4	B.			
024356 W PERSEI—												
	3072.6	8.9	B,	3079.6	8.8	Pt,	3084.0	8.5	Br,	3088.6	8.8	B.
030514 U ARIETIS—												
	3072.6<14.0		B,	3076.4<13.8		Gi,	3078.5<13.1		Y,	3103.6<13.1		Fn.
031401 X CETI—												
	3056.3	9.6	L,	3066.2	9.3	L,	3072.6	8.4	B,	3072.7	8.3	Wf,
	3078.7	8.8	Wf,	3079.6	8.7	Pt,	3090.7	8.6	Wf.			
032043 Y PERSEI—												
	3076.7	8.4	Pt,	3077.5	9.8	Pi,	3088.6	8.8	B.			
032335 R PERSEI—												
	3062.4	11.0	Gi,	3074.4	10.1	Gi,	3076.7	9.5	Pt,	3077.5	8.9	Pi,
	3083.7	9.4	B.									
042209 R TAURI—												
	3076.7	12.5	Pt,	3085.5<11.7		Pi.						
042215 W TAURI—												
	3067.7	10.0	O,	3073.6	9.5	Sg,	3076.7	9.5	Pt,	3077.6	10.3	V,
	3078.6	10.0	Pi,	3079.7	9.8	Mu,	3083.8	10.1	Br,	3084.5	10.0	Pi,
	3089.7	9.5	Sg,	3094.7	9.6	B,	3099.7	9.5	Sg.			
042309 S TAURI—												
	3085.5<11.7		Pi.									
043065 T CAMELOPARDALIS—												
	3062.7	13.5	L.									
043208 RX TAURI—												
	3076.5	13.7	B,	3085.5<11.9		Pi.						
043274 X CAMELOPARDALIS—												
	3076.7	9.3	Pt,	3080.8	8.6	M,	3084.5	8.8	Pi,	3096.6	8.4	B.
044617 V TAURI—												
	3076.7	10.1	Pt,	3078.6	10.5	Pi,	3086.7	10.7	Lc.			
045307 R ORIONIS—												
	3075.4	12.5	Gi,	3085.6<12.1		Pi,	3103.6	13.0	Fn.			
045514 R LEPORIS—												
	3056.3	10.2	L,	3058.3	8.8	Rk,	3065.4	8.8	Rk,	3074.3	10.6	L,
	3076.7	10.5	Pt,	3078.3	9.0	Rk,	3085.6	10.6	Pi,	3099.5	9.8	Ya.
050003 V ORIONIS—												
	3076.5	8.9	Y,	3076.6	9.2	B,	3078.5	9.8	Pt,	3085.6	9.4	Pi,
	3103.6	10.8	Fn.									

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
050022 **T LEPORIS—**												
	3076.7	8.4	Pt,	3088.6	7.8	B,	3099.5	8.2	Ya.			
050953 R AURIGAE—												
	3075.7	12.5	Lv,	3076.7	12.5	Pt,	3077.5	<11.5	Pi,	3077.6	<11.4	V,
	3083.9	<11.0	Br,	3084.8	<12.0	M.						
052034 S AURIGAE—												
	3060.3	10.0	L,	3078.6	9.8	Pi.						
052036 W AURIGAE—												
	3075.3	13.8	Gi,	3077.5	<12.2	Pi.						
052404 **S ORIONIS—**												
	3083.6	13.2	B,	3085.6	<12.1	Pi.						
053005a **T ORIONIS—**												
	3056.3	10.2	L,	3060.3	11.0	L,	3062.3	10.8	L,	3062.3	10.8	An,
	3074.3	9.9	L,	3076.7	10.8	Pt,	3079.6	<11.2	Mu,	3085.6	10.4	Pi,
	3086.7	10.5	Wl,	3088.6	11.1	B,	3099.5	10.4	Pt,	3099.6	10.7	Ya.
053068 S CAMELOPARDALIS—												
	3076.7	8.5	Pt,	3080.8	8.6	M,	3084.5	8.6	Pi,	3088.6	8.6	Ya.
053531 U AURIGAE—												
	3076.6	13.3	B,	3103.6	11.0	Fn.						
054319 SU TAURI—												
	3058.3	9.4	Rk,	3062.3	9.4	An,	3062.3	9.4	L,	3062.8	9.8	Hj,
	3063.3	9.5	L,	3068.7	9.4	Wf,	3072.7	9.4	Wf,	3073.7	9.4	Wf,
	3074.3	9.4	L,	3074.6	9.5	B,	2075.5	9.6	O,	3076.7	9.5	Pt,
	3076.8	10.0	Hj,	3077.5	9.6	Pt,	3077.7	9.4	Br,	3078.3	9.5	Rk,
	3078.5	9.6	Pt,	3078.6	9.5	Pi,	3078.7	9.4	Wf,	3079.6	9.0	V,
	3080.5	9.5	Pt,	3080.8	9.8	Hj,	3082.5	9.6	Pt,	3082.8	10.0	Hj,
	3083.7	10.0	Hj,	3083.7	9.5	Br,	3083.8	9.4	Wf,	3085.6	9.7	Je,
	3085.7	9.9	Hj.	3086.7	9.5	Wf,	3090.7	94.	Wf,	3099.5	9.5	Pt,
	3102.7	9.5	Pt.									
054615a Z TAURI—												
	3078.5	12.6	Y.									
054615b RS TAURI—												
	3078.5	9.2	Y.									
054615c RU TAURI—												
	3078.5	12.7	Y.									
054920a U ORIONIS—												
	3052.6	10.7	Lv,	3055.6	10.4	Lv,	3062.8	10.3	Hj,	3067.7	10.4	Ml,
	3069.7	<10.2	Hj,	3070.6	10.5	Lv,	3075.5	10.2	O,	3076.7	10.8	Pt,
	3076.8	<10.2	Hj,	3078.6	10.8	Pi,	3080.7	<10.6	Hj,	3082.8	<10.6	Hj,
	3083.6	11.4	Lv,	3083.7	11.0	Hj,	3085.6	10.2	Je,	3085.7	<10.6	Hj,
	3086.7	10.8	Wl,	3094.7	10.7	B.						
054920b UW ORIONIS—												
	3052.6	11.1	Lv,	3055.6	11.0	Lv,	3070.6	10.4	Lv,	3083.6	11.2	Lv.
054974 V CAMELOPARDALIS—												
	3060.5	12.3	Gi,	3076.6	13.0	B,	3078.5	<13.0	Y,	3084.5	<12.2	Pi.
055353 Z AURIGAE—												
	3072.7	10.5	Wf,	3076.6	10.5	B,	3076.7	10.9	Pt,	3077.5	10.8	Pi,
	3078.7	10.8	Wf,	3083.9	11.1	Br,	3090.7	11.0	Wf.			
060450 X AURIGAE—												
	3076.7	11.5	Pt,	3099.5	9.4	B,	3122.5	8.4	Mc,			
060547 SS AURIGAE—												
	3056.3	<14.5	L,	3057.7	<13.3	L,	3060.3	<13.3	L,	3060.4	<13.9	Gi,
	3062.3	<13.8	Gi,	3062.3	<13.3	L,	3064.7	<12.4	L,	3068.3	<12.4	Gi,
	3068.7	<11.0	L,	3069.4	<11.0	Rk,	3069.9	<10.8	Br,	3074.5	<13.9	Gi,
	3074.3	<13.9	L,	3074.6	<14.0	B,	3075.3	<13.9	Gi,	3075.5	<12.4	O,
	3075.5	<12.4	Y,	3076.3	14.3	Gi,	3076.6	<14.5	L,	3076.7	13.5	Gi,
	3076.7	<12.6	Pt,	3077.3	11.2	Gi,	3077.5	10.9	Pi,	3077.5	10.9	Pt,
	3077.7	10.9	Br,	3078.3	11.0	Gi,	3078.3	10.9	Rk,	3078.6	10.9	Pi,
	3079.6	11.0	Y,	3079.6	11.1	Pt,	3079.6	10.7	V,	3079.8	11.2	M,
	3080.5	11.5	Pt,	3080.5	11.1	Pi,	3080.8	10.8	M,	3081.5	12.6	O,
	3081.5	11.7	Pt,	3082.5	11.9	Pt,	3083.7	<11.0	Br,	3083.8	13.0	Pt,

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
060547 SS AURIGAE—Continued.												
	3083.9	<11.8	Br,	3084.3	13.6	Gi,	3084.3	13.7	L,	3084.5	<12.6	Pt,
	3084.8	13.2	M,	3085.5	<12.4	Pt,	3088.5	<12.4	Pi,	3088.5	<12.4	E,
	3085.7	<11.8	Br,	3094.5	<13.0	Wl,	3099.5	<12.6	Pt,	3102.7	<12.6	Pt,
061647 V AURIGAE—												
	3084.8	11.5	M.									
***061702* V MONOCEROTIS—**												
	3085.6	<12.1	Pi,	3101.6	12.9	Pt.						
063159 U LYNCIS—												
	3074.6	13.3	B,	3078.5	<12.6	Y,	3080.5	<12.6	Pi.			
063308 R MONOCEROTIS—												
	3085.6	<11.7	Pi,	3099.6	11.7	B.						
063558 S LYNCIS—												
	3080.5	<11.9	Pi,	3084.0	<11.9	Br.						
064030 X GEMINORUM—												
	3060.5	13.1	Gi,	3075.4	12.6	Gi.						
064707 W MONOCEROTIS—												
	3079.6	10.4	Pt,	3085.6	11.0	Pi,	3100.6	9.3	B.			
064932 NOVA GEMINORUM No. 2—												
	3076.7	13.8	L.									
065111 Y MONOCEROTIS—												
	3055.6	11.5	Lv,	3075.6	10.5	Lv,	3076.5	10.8	Y,	3076.6	10.5	B,
	3078.6	10.6	Pi,	3079.6	10.6	V,	3083.6	10.5	Lv.			
***065208* X MONOCEROTIS—**												
	3060.3	9.0	L.									
065355 R LYNCIS—												
	3076.4	<12.4	Gi,	3078.5	<13.0	Y,	3080.5	<11.9	Pi.			
070109 V CANIS MINORIS—												
	3076.6	12.5	B,	3085.6	<12.1	Pi,	3100.6	13.6	B.			
070122a R GEMINORUM—												
	3072.7	8.0	B,	3076.7	8.1	Pt,	3079.8	8.8	M,	3083.6	8.8	Lv,
	3100.6	9.0	B.									
070122b Z GEMINORUM—												
	3072.7	12.2	B,	3076.7	12.6	Pt,	3079.8	<11.6	M,	3083.6	12.6	Lv,
	3100.6	12.5	B.									
070122c TW GEMINORUM—												
	3072.7	8.0	B,	3079.8	8.0	M,	3100.6	8.0	B.			
070310 R CANIS MINORIS—												
	3056.3	8.4	L,	3067.7	8.3	Ml,	3074.2	8.4	An,	3074.3	8.4	L,
	3078.6	8.5	Pi,	3081.5	8.2	O,	3093.6	8.4	B.			
071713 V GEMINORUM—												
	3074.7	<14.0	B,	3078.6	11.6	Pi.						
072708 S CANIS MINORIS—												
	3062.7	12.8	L,	3076.7	12.9	Pt,	3078.3	<10.0	Rk,	3085.6	<11.7	Pi,
	3086.7	<10.0	Lc,	3093.6	11.6	B.						
072811 T CANIS MINORIS—												
	3079.6	9.7	Pt,	3081.5	9.6	O,	3083.6	9.4	B,	3099.6	9.4	B.
073508 U CANIS MINORIS—												
	3056.3	9.8	L,	3074.3	10.3	L,	3079.6	10.5	Pt,	3081.5	10.5	O,
	3085.6	10.4	Pi,	3093.6	10.5	B.						
073723 S GEMINORUM—												
	3074.7	9.3	B,	3078.6	9.6	Pi,	3079.6	9.7	Pt,	3079.6	9.7	V,
	3099.6	9.9	B.									
074323 T GEMINORUM—												
	3074.7	8.7	B,	3078.6	9.0	Pi,	3079.6	9.0	V,	3080.8	9.1	M,
	3099.6	8.5	B.									
074922 U GEMINORUM—												
	3056.3	<14.1	L,	3057.7	<12.3	L,	3058.3	<12.3	Rk,	3060.3	13.9	L,
	3060.4	<13.7	Gi,	3062.3	<12.5	L,	3062.4	13.9	Gi,	3064.7	<13.3	L,
	3068.8	<12.4	Wf,	3072.6	10.0	B,	3072.7	10.4	Wf,	3073.6	10.7	B,
	3073.7	10.1	Wf,	3074.3	10.9	L,	3074.5	11.5	Gi,	3074.6	11.2	B,

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
074922 U GEMINORUM—Continued.												
	3074.7	11.3	L,	3075.4	12.1	Gi,	3075.5	9.1	O,	3075.5	11.8	Y,
	3076.4	13.0	Gi,	3076.6	13.6	B,	3076.6	13.3	L,	3076.8	<13.3	Pt,
	3077.4	13.7	Gi,	3077.4	<12.3	Rk,	3077.5	<13.3	Pt,	3078.3	<12.4	Rk,
	3078.5	<13.3	Pt,	3078.6	13.9	Wf,	3078.6	<12.3	Pi,	3079.6	13.6	B,
	3079.6	<13.3	Pt,	3079.8	<12.4	M,	3080.5	<12.4	Pt,	3081.5	12.4	O,
	3082.5	<12.4	Pt,	3083.6	13.9	B,	3083.7	<11.7	Br,	3083.8	<13.3	Pt,
	3084.5	<13.3	Pt,	3085.5	<12.4	Pt.	3088.5	<13.7	Wl,	3090.8	13.9	Wf,
	3094.5	<13.0	Wl,	3099.5	<13.3	Pt,	3100.6	14.0	B,	3101.6	<13.3	Pt,
	3102.7	<14.1	Pt.									
075612 U PUPPIS—												
	3103.6	<12.5	Fn.									
081112 R CANCRI—												
	3060.3	9.5	L,	3076.7	9.3	L,	3076.7	9.1	B,	3079.6	9.5	Pt,
	3080.6	9.3	Pi.									
081617 V CANCRI—												
	3074.5	7.9	Gi,	3076.7	7.7	B,	3079.8	7.5	Pt,	3080.6	8.0	Pi,
	3083.8	7.5	Br,	3084.8	7.0	M,	3094.6	8.1	Wl.			
082405 RT HYDRAE—												
	3060.3	7.7	L.									
083019 U CANCRI—												
	3072.8	<13.3	Wf,	3078.5	<14.0	Wf,	3080.6	<11.9	Pi,	3090.5	14.0	Wf.
083350 X URSAE MAJORIS—												
	3074.6	11.8	B,	3078.8	11.7	Pt,	3080.6	<11.5	Pi.			
084803 S HYDRAE—												
	3072.7	11.9	B,	2076.8	11.8	Pt,	3083.8	<10.7	Br.			
085008 T HYDRAE—												
	3064.7	11.4	L,	3076.8	11.0	Pt,	3083.6	10.3	B,	3083.9	<10.0	Br.
085120 T CANCRI—												
	3062.7	9.0	L,	3078.8	8.4	Pt,	3080.6	9.2	Pi.			
090024 S PYXIDIS—												
	3102.7	11.4	Pt.									
090151 V URSAE MAJORIS—												
	3073.6	9.8	Sg,	3073.6	9.8	Mu,	3079.6	8.7	Mu,	3089.7	9.5	Sg,
	3093.6	10.1	B.									
090425 W CANCRI—												
	3062.7	9.1	L,	3072.8	10.0	Wf,	3078.8	10.4	Wf,	3079.6	10.3	V,
	3080.6	10.4	Pi,	3090.8	10.7	Wf,	3096.7	11.0	B.			
093014 X HYDRAE—												
	3102.7	10.9	Pt.									
093178 Y DRACONIS—												
	3078.6	13.0	Y.									
093934 R LEONIS MINORIS—												
	3062.3	10.3	L,	3062.3	10.3	An,	3072.7	9.6	B,	3078.8	9.7	Pt,
	3084.6	9.1	Pc,	3090.6	8.5	Pc,	3094.6	7.9	B,	3101.6	7.7	Pc.
094211 R LEONIS—												
	3076.7	7.0	O,	3076.8	6.3	Pt,	3084.6	7.1	Su,	3084.6	7.0	Pc,
	3084.8	7.3	M,	3086.0	7.2	Br,	3090.6	7.2	Pc,	3090.9	8.1	Br,
	3094.6	7.1	B,	3101.6	8.0	Pc.						
094512 X LEONIS—												
	3056.7	12.3	L,	3057.7	<13.8	L,	3062.7	<13.3	L,	3064.7	<12.8	L,
	3074.7	12.2	L,	3076.7	12.2	L.						
094622 Y HYDRAE—												
	3078.8	6.0	Pt.									
095421 V LEONIS—												
	3072.8	10.7	Wf,	3076.8	10.7	Pt,	3078.8	10.8	Wf,	3084.8	11.5	M,
	3090.8	11.0	Wf,	3093.7	11.3	B.						
103212 U HYDRAE—												
	3062.7	4.9	L.									
103769 R URSAE MAJORIS—												
	3078.8	11.7	Pt,	3084.5	<11.5	Pi,	3090.6	12.0	Pc,	3093.6	12.2	B.

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
104620 V HYDRAE—												
	3062.7	7.1	L,	3076.8	7.0	Pt.						
104814 W LEONIS—												
	3078.8	9.3	Pt,	3079.6	9.5	Y,	3085.6	9.2	Fn,	3103.6	9.2	Fn.
110506 S LEONIS—												
	3078.8	11.1	Pt.									
115919 R COMAE BERENICES—												
	3083.9	<11.8	Br.									
120905 T VIRGINIS—												
	3083.9	<11.4	Br.									
121418 R CORVI—												
	3062.7	11.9	L,	3074.7	11.3	L,	3076.8	11.2	Pt.			
122001 SS VIRGINIS—												
	3062.7	6.6	L.									
122532 T CANUM VENATICORUM—												
	3076.8	9.5	Pt,	3079.8	9.8	M,	3084.0	10.2	Br.			
122803 Y VIRGINIS—												
	3062.7	11.0	L,	3084.0	9.7	Br.						
123160 T URSAE MAJORIS—												
	3073.6	8.3	Sg,	3073.6	8.6	Mu,	3076.8	9.2	Pt,	3079.7	9.4	Mu,
	3079.8	8.8	M,	3084.0	8.9	Br,	3084.7	9.4	Su,	3089.7	9.2	Sg,
	3090.6	9.7	Pc,	3099.7	<9.8	Sg,	3119.5	<9.8	Mc.			
123307 R VIRGINIS—												
	3062.7	6.8	L,	3076.8	6.5	Pt.						
123459 RS URSAE MAJORIS—												
	3069.9	<10.6	Br,	3073.7	14.2	Wf,	3079.8	<12.5	M,	3084.0	<11.8	Br,
	3090.6	<14.0	Pc,	3119.5	<9.9	Mc.						
123961 S URSAE MAJORIS—												
	3057.7	9.0	L,	3067.7	8.3	Ml,	3073.6	8.6	Mu,	3073.6	8.5	Sg,
	3076.8	9.0	Pt,	3079.7	8.6	Mu,	3079.8	9.0	M,	3084.1	8.8	Br,
	3084.7	8.8	Su,	3089.7	8 8	Sg,	3090.6	8.7	Pc,	3099.7	8.5	Sg,
	3104.6	8.6	Cg,	3119.5	7.7	Mc.						
124606 U VIRGINIS—												
	3076.8	8.9	Pt.									
132422 R HYDRAE—												
	3048.3	4.4	Kd,	3050.4	4.4	Kd,	3053.4	4.5	Kd,	3054.4	4.4	Kd,
	3057.3	4.4	Kd,	3058.3	4.5	Kd,	3060.3	4.6	Kd,	3062.3	4.7	Kd,
	3062.7	4.4	L,	3062.7	4.6	Gi,	3064.7	4.5	L,	3065.3	4.7	Kd,
	3068.7	4.4	L,	3074.4	5.0	Kd,	3076.7	4.6	L.			
132706 S VIRGINIS—												
	3076.8	9.5	Pt,	3084.8	8.7	M.						
133273 T URSAE MINORIS—												
	3073.7	12.3	Wf,	3086.6	13.0	Wf.						
134440 R CANUM VENATICORUM—												
	3076.8	9.3	Pt,	3084.8	9.0	M.						
140113 Z BOOTIS—												
	3084.8	10.0	M.									
141567 U URSAE MINORIS—												
	3076.8	10.5	Pt,	3090.6	9.7	Pc.						
141954 S BOOTIS—												
	3062.7	10.8	Gi,	3062.7	11.3	L,	3076.8	11.9	Pt,	3079.8	<12.0	M.
142539 V BOOTIS—												
	3062.7	9.4	L,	3076.8	8.9	Pt,	3080.8	8.9	M,	3081.7	9.1	Su,
	3109.5	8.5	Mc.									
142584 R CAMELOPARDALIS—												
	3060.5	13 0	Gi,	3073.7	13.3	Wf,	3076.4	13 3	Gi,	3085.7	<11.8	Br,
	3086.6	13.3	Wf.									
143227 R BOOTIS—												
	3076.8	8.0	Pt,	3081.7	8.4	Su,	3484.0	8.3	Br,	3084.8	8.5	M.
144918 U BOOTIS—												
	3062.7	11.3	Gi,	3076.7	11.0	Gi,	3084.8	11.0	M.			

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Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
150018 **RT LIBRAE—**												
	3083.8	10.9	Pt.									
150605 **Y LIBRAE—**												
	3064.7	8.8	L,	3083.9	7.6	Pt.						
151520 **S LIBRAE—**												
	3074.7	11.2	L,	3083.9	11.9	Pt.						
151714 S SERPENTIS—												
	3064.7<13.0		L.									
151731 S CORONAE BOREALIS—												
	3076.8	8.0	Pt,	3081.7	8.2	Su.						
151822 **RS LIBRAE—**												
	3074.7	11.7	L.									
153378 S URSAE MINORIS—												
	3073.7	11.4	Wf,	3078.8	11.2	Pt,	3086.6	11.6	Wf.			
154428 R CORONAE BOREALIS—												
	3057.7	6.4	L,	3062.7	6.5	Gi,	3062.7	6.3	L,	3064.7	6.3	L,
	3068.7	6.1	L,	3074.7	6.2	L,	3076.7	6.2	L,	3076.7	6.3	Gi,
	3076.8	6.2	Pt,	3078.8	6.2	Pt,	3080.8	6.2	Pt,	3080.8	6.2	M,
	3081.7	6.6	Su,	3083.9	6.1	Pt,	3085.9	6.0	Pt,	3086.0	6.3	Br,
	3087.9	6.1	Pt,	3088.8	6 9	Ms,	3088.8	6.3	Wg,	3090.9	6.5	Br,
	3093.9	6.2	Pt,	3102.7	6.2	Pt.						
154615 R SERPENTIS—												
	3078.8	8.0	Pt.									
154639 V CORONAE BOREALIS—												
	3078.8	7.7	Pt,	3080.8	8.6	M,	3084.0	8.2	Br.			
155018 **RR LIBRAE—**												
	3074.7	13.5	L.									
155823 **RZ SCORPII—**												
	3083.9	12.6	Pt.									
160021 **Z SCORPII—**												
	3076.7	9.5	L.									
160210 U SERPENTIS—												
	3078.8	8.8	Pt.									
160625 RU HERCULIS—												
	3078.8	10.5	Pt.									
161607 **W OPHIUCHI—**												
	3083.9	11.8	Pt.									
162112 **V OPHIUCHI—**												
	3083.9	8.0	Pt.									
162119 U HERCULIS—												
	3068.7	7.6	Gi,	3083.9	7.1	Pt.						
162807 SS HERCULIS—												
	3074.7	11.8	L,	3083.9	11.1	Pt.						
163266 R DRACONIS—												
	3083.9	11.4	Pt,	3084.8	12.5	M.						
164715 S HERCULIS—												
	3068.7	7.4	Gi,	3083.9	7.1	Pt.						
170215 **R OPHIUCHI—**												
	3083.9	7.5	Pt.									
170627 RT HERCULIS—												
	3083.9	10.7	Pt.									
171401 Z OPHIUCHI—												
	3076.7	8.0	Gi,	3083.9	7.9	Pt.						
171723 RS HERCULIS—												
	3083.9	12.4	Pt.									
172809 RU OPHIUCHI—												
	3083.9	12.0	Pt.									
175111 RT OPHIUCHI—												
	3085.9	11.3	Pt.									
175458a T DRACONIS—												
	3062.7	12.5	Gi.									

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
175519 RY HERCULIS—												
	3085.9	9.3	Pt.									
180531 T HERCULIS—												
	3057.7	9.2	L,	3074.7	9.8	L,	3085.9	11.1	Pt.			
180666 X DRACONIS—												
	3085.9	11.0	Pt.									
181031 TV HERCULIS—												
	3060.2	9.6	L,	3074.7	10.3	L.						
181103 RY OPHIUCHI—												
	3068.7	8.8	Gi,	3093.9	8.4	Pt.						
181136 W LYRAE—												
	3060.2	8.5	L,	3074.7	8.3	L,	3085.9	8.7	Pt.			
182224 SV HERCULIS—												
	3074.7	<13.0	L.									
182306 T SERPENTIS—												
	3093.9	11.1	Pt.									
183149 SV DRACONIS—												
	3078.5	<13.0	Y.									
183225 RZ HERCULIS—												
	3085.9	9.0	Pt.									
183308 X OPHIUCHI—												
	3076.7	8.0	L,	3093.9	7.6	Pt.						
184205 R SCUTI—												
	3062.7	5.0	L,	3068.7	4.8	L,	3076.7	5.0	L,	3083.9	5.6	Pt.
	3085.9	5.6	Pt,	3093.9	5.5	Pt.						
184300 NOVA AQUILAE #3—												
	3076.7	9.5	L,	3083.9	10.0	Pt,	3093.9	10.1	Pt.			
185634 Z LYRAE—												
	3060.2	12.9	L.									
190108 R AQUILAE—												
	3093.9	11.8	Pt.									
190926 X LYRAE—												
	3085.9	9.0	Pt.									
190967 U DRACONIS—												
	3085.9	9.1	Pt.									
191350 TZ CYGNI—												
	3078.5	10.6	Y,	3085.9	10.9	Pt.						
191637 U LYRAE—												
	3085.9	10.1	Pt.									
192928 TY CYGNI—												
	3085.9	10.6	Pt.									
193449 R CYGNI—												
	3052.6	<12.8	Lv,	3072.6	<11.9	Br,	3082.6	13.0	Pc,	3084.1	<11.8	Br,
	3084.6	12.6	Pc.									
194048 RT CYGNI—												
	3062.3	7.8	Gi,	3071.6	7.8	Hj,	3076.3	7.3	Gi,	3084.1	7.5	Br,
	3084.5	7.0	Hj,	3085.9	7.2	Pt.						
194348 TU CYGNI—												
	3078.4	<11.2	Rk,	3084.1	11.5	Br,	3085.9	12.1	Pt.			
194632 χ CYGNI—												
	3051.6	10.8	Lc,	3085.9	11.7	Pt.						
195653 NOVA CYGNI #3—												
	3060.2	9.6	L,	3060.3	10.4	Gi,	3078.5	9.6	Pt,	3081.5	10.0	Pt,
	3084.2	9.5	An,	3084.3	9.5	L,	3084.5	9.6	Pt,	3093.5	9.7	Pt.
	3099.5	9.9	Pt.									
195849 Z CYGNI—												
	3072.6	13.5	Wf,	3078.6	13.8	Wf,	3085.9	12.6	Pt,	3086.6	13.5	Wf.
200212 SY AQUILAE—												
	3060.2	11.7	L.									
200357 S CYGNI—												
	3093.9	13.1	Pt.									

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs
200647 SV CYGNI—												
	3079.6	8.8	Mu.									
200715a S AQUILAE—												
	3047.9	9.4	Kd.									
200747 RX CYGNI—												
	3079.6	7.8	Mu.									
200906 Z AQUILAE—												
	3047.9	10.2	Kd.									
200938 RS CYGNI—												
	3060.3	7.6	L,	3084.2	8.0	L,	3084.2	7.6	An,	3093.9	7.3	Pt.
201130 SX CYGNI—												
	3078.5	<12.9	Y.									
201647 U CYGNI—												
	3051.6	8.4	Lc,	3060.3	8.0	Gi,	3077.5	7.5	Pt,	3079.6	7.7	Mu.
202954 ST CYGNI—												
	3077.5	10.6	Pt,	3078.5	10.0	Y.						
203226 V VULPECULAE—												
	3077.5	8.5	Pt.									
203847 V CYGNI—												
	3060.3	8.7	Gi.									
204016 T DELPHINI—												
	3072.6	9.5	Wf,	3079.5	9.7	Pt.						
204104 W AQUARII—												
	3060.2	<12.9	L.									
204846 RZ CYGNI—												
	3076.3	12.9	Gi.									
205017 X DELPHINI—												
	3052.6	12.0	Lv.									
205923 R VULPECULAE—												
	3051.9	8.5	Kd,	3064.9	9.2	Kd,	3076.2	10.2	Gi.			
210129 TW CYGNI—												
	3078.5	10.5	Y.									
210504 RS AQUARII—												
	3060.2	10.7	L.									
210868 T CEPHEI—												
	3060.2	7.6	L,	3062.4	7.4	L,	3071.6	8.0	Mu,	3072.6	8.1	Mu,
	3073.6	8.0	Mu,	3074.6	7.9	Mu,	3075.6	7.9	Mu,	3076.6	7.8	Mu,
	3077.5	7.6	Pt,	3077.6	7.8	Mu,	3078 6	7.8	Mu,	3079.6	7.7	Mu,
	3080.6	7.7	Mu,	3081.6	7.7	Mu,	3082.6	7.7	Mu,	3088.5	8.2	Ya,
	3088.6	7.6	Cg,	3088.6	7.6	Ms,	3098.6	7.5	Mu,	3099.6	7.5	Mu.
211614 X PEGASI—												
	3060.2	12.0	Gi.									
213244 W CYGNI—												
	3056.3	5.6	L,	3068.3	5.8	L,	3084.3	6.1	L.			
213678 S CEPHEI—												
	3076.4	8.9	Gi,	3077.5	10.0	Pt,	3085.6	9.5	Br.			
213843 SS CYGNI—												
	3052.6	11.9	Lv,	3055.6	11.6	Lv,	3056.3	12.0	L,	3058.2	11.8	L,
	3058.3	11.9	Rk,	3060.2	12.1	L,	3060.3	11.9	Gi,	3061.6	11.9	Lv,
	3062.3	11.8	L,	3062.3	11.8	Gi,	3066.2	11.9	L,	3068.3	11.9	L,
	3068.7	12.0	Wf,	3071.6	<10.2	Hj,	3072.6	11.9	B,	3072.6	11.9	Wf,
	3072.6	<10.9	Br,	3073.6	12.0	B,	3073.7	12.0	Wf,	3074.2	12.0	An,
	3074.2	12.0	L,	3074.5	11.9	B,	3075.3	12.0	Gi,	3075.5	11.7	Y,
	3076.3	12.0	Gi,	3076.5	11.9	B,	3076.7	11.9	L,	3077.3	12.0	Gi,
	3077.5	11.8	Pt,	3077.5	<11.3	Hj,	3077.7	<11.5	Br,	3078.3	11.9	Rk,
	3078.5	11.8	Y,	3078.5	11.8	Pt,	3078.6	11.9	Wf,	3079.5	<10.9	Ms,
	3079.5	11.9	Pt,	3079.7	<10.9	Mu,	3080.5	11.9	Pt,	3081.5	11.9	Pt,
	3082.5	11.8	Pt,	3082.6	11.7	Pc,	3083.5	11.8	Pt,	3083.5	11.3	B,
	3083.8	11.0	Wf,	3084.2	9.6	Gi,	3084.3	9.3	An,	3084.3	9.2	L,
	3084.5	8.7	Pt,	3084.5	9.1	Hj,	3084.6	8.9	Pc,	3085.5	8.3	Pt,
	3085.5	8.2	Ya,	3085.6	8.4	Br,	3086.5	8.2	Ms,	3086.6	8.4	Wf,

VARIABLE STAR OBSERVATIONS, January 20 to February 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—*Continued.*												
	3088.5	8.3	Ms,	3088.5	8.2	Ya,	3088.5	8.3	E,	3088.5	8.2	Pi,
	3089.5	8.3	Wl,	3090.5	8.5	Ms,	3090.6	8.6	Wf,	3093.9	8.3	Pt,
	3094.5	8.6	Ms,	3099.5	9.8	Ms,	3099.6	9.8	Wf,	3099.9	9.5	Pt,
	3101.6	10.8	Pt.									
214024 RR PEGASI—												
	3077.5	10.0	Pt.									
220613 Y PEGASI—												
	3060.3	<13.4	Gi.									
220714 RS PEGASI—												
	3060.3	12.9	Gi.									
222439 S LACERTAE—												
	3073.6	13.1	B,	3077.3	13.0	Gi.						
223841 R LACERTAE—												
	3077.3	14.0	Gi.									
225914 RW PEGASI—												
	3073.6	<12.7	B,	3085.6	<11.2	Br.						
230110 R PEGASI—												
	3071.6	<9.3	Hj,	3077.5	10.6	Pt,	3084.5	<9.3	Hj.			
230759 V CASSIOPEIAE—												
	3068.4	9.4	Gi,	3072.6	9.5	B,	3077.5	8.6	Pt,	3077.5	9.0	V,
	3079.6	9.2	Mu,	3090.6	8.3	B.						
231425 W PEGASI—												
	3055.6	8.8	Lv,	3060.3	8.4	L,	3084.2	7.9	L,	3084.2	8.2	An.
231508 S PEGASI—												
	3074.5	12.5	B.									
233335 ST ANDROMEDAE—												
	3072.6	8.2	Wf,	3077.5	8.6	Pt,	3078.6	9.0	Wf,	3086.6	8.6	Wf,
	3088.5	8.6	Pi,	3088.5	8.7	E,	3090.5	8.6	B.			
233815 R AQUARII—												
	3047.9	7.1	Kd,	3051.9	6.6	Kd,	3058.9	6.7	Kd,	3064.9	6.3	Kd,
	3073.9	7.0	Kd,	3077.5	6.4	Pt.						
233956 Z CASSIOPEIAE—												
	3072.6	11.6	Wf,	3078.6	11.8	Wf,	3083.6	11.7	B,	3086.6	12.1	Wf.
235053 RR CASSIOPEIAE—												
	3068.4	10.7	Gi,	3090.6	10.9	B.						
235209 V CETI—												
	3056.3	12.3	L,	3074.2	<12.7	L,	3076.3	<13.6	Gi,	3077.5	12.2	Pt.
235350 R CASSIOPEIAE—												
	3068.5	8.7	Gi,	3088.5	9.5	E,	3088.5	9.6	Pi.	3088.6	9.4	Ya.
	3090.6	9.2	B.									
235525 Z PEGASI—												
	3077.5	11.7	Pt.									
235715 W CETI—												
	3062.2	8.6	Gi,	3075.3	8.7	Gi.						
235855 Y CASSIOPEIAE—												
	3068.4	10.5	Gi,	3072.6	10.4	B,	3077.5	<10.6	V,	3090.6	9.9	B.
235939 SV ANDROMEDAE—												
	3073.6	12.6	B,	3078.5	12.5	Pt,	3078.5	13.2	Y,	3088.5	<11.6	Pi,
	3088.5	<11.9	E,	3103.5	<12.3	Fn.						

Total Observations: 993. Total Stars: 232; Observers: 31

GENERAL NOTES.

Father G. Luis, S.J. died recently at the age of seventy-six. He was a pupil of Secchi and recently vice-Director of the Vatican Observatory. For many years his chief activity has been with the Vatican's share in the Astrographic Chart.

Sir W. H. M. Christie, former Astronomer Royal at the Greenwich Observatory, died on January 22, 1922, in his seventy-seventh year. He was on his way to Mogadar, in North Africa, and died at sea. He was appointed Chief Assistant at the Royal Observatory, Greenwich in 1870, and in 1881 succeeded Sir George Airy as Astronomer Royal. He retired in 1910. He was the founder of the astronomical magazine *"The Observatory."*

Dr. J. H. Jeans was awarded the gold medal of the Royal Astronomical Society, at its meeting January 13, 1922, for his investigations in the theories of Cosmogony.

Dr. Otto Klotz, Director of the Dominion Observatory, gave an illustrated address before the Brooklyn Institute of Arts and Sciences on "Astronomy in Canada" on February 28, 1922.

American Delegates to the International Astronomical Union. —The following delegation from this country will be present at the meeting of the International Astronomical Union, opening in Rome on May 2.

Messrs: Schlesinger (Chairman), Aitken, Curtis, Lee, Miller, Russell, St. John, Seares, and Shapley.

Dr. Otto Klotz, Director of the Dominion Observatory, will be the delegate and representative of Canada at the approaching meeting of the International Astronomical Union.

Dr. E. Deville, Surveyor General of Canada, will be the representative of Canada at the International Union of Geodesy and Geophysics.

Professor C. A. Chant of the University of Toronto, Editor of the *Journal* of the Royal Astronomical Society of Canada, writes that he is to go to Australia to observe the total eclipse of the sun, Sept. 20, 1922. He will be with the Lick Observatory party on the west coast of Australia. He is busy now completing a camera of six inches aperture and focal length eleven feet, which is to be used in taking photographs for the Einstein effect. Mr. Chant will be accompanied by his wife and daughter. They expect to leave in June and return in November.

An Astronomy Club for Amateurs, proposed recently by Mr. Curt B. Muller of Cleveland, held a meeting for the purpose of acquaintance and organization, on Monday, March 13, at the University Club in Cleveland. Mr. Muller made the suggestion in the Club Notes of Cleveland's leading daily, a few weeks ago, and some forty people of both sexes responded and signified a desire to join the Club. Several of the prospective members have telescopes, among them being a 9½ inch Refractor, a 5½ inch Refractor, several four inch, and a Mellish 9½ inch Reflector. The Club also will have access to the 10½ inch Refractor in the Observatory of the Case School of Applied Sciences. We will publish further notices regarding the activities of this Club from time to time.

Those who may care to communicate with this Club, may address Mr. Curt B. Muller at No. 940, The Leader-News Bldg., Cleveland.

The Eclipse of Sept. 21, 1922.—The party from the Royal Observatory, Greenwich, to observe the eclipse of Sept. 21 next, sailed from Liverpool on Jan. 28 by the S. S. "Mentor." It is expected that they will arrive at Singapore in time to catch the 'Islander,' which sails for Christmas Island about March 7. The principal instrument taken is the Greenwich 13-inch astrographic telescope with the 10-inch guiding telescope. This instrument has been adapted for the latitude of Christmas Island by Sir Howard Grubb. The Christmas Island Phosphate Company has very kindly offered to assist the expedition in all ways possible, and are preparing a site for the instrument, as well as placing a bungalow at the disposal of the observers. It is hoped that the telescope will be erected for observations to begin in May. Besides check-plates of the eclipse field, photographs of Kapteyn Selected Areas in Declination 30° S. and 15° S. will be taken. The magnitudes will be standardized by exposing the plates on the Kapteyn Areas in Dec. 15° N., for which magnitudes are now available from work done at Greenwich with the 26-inch refractor. This work will be carried over as large a region in R. A. as possible. The observers are Mr. Jones and Mr. Melotte, while Mrs. Jones also accompanies the expedition. (*The Observatory*, Feb. 1922.)

The Absolute Magnitude of Cluster Type Variables:—The typical Cepheid variable stars, with periods longer than a day, as a class have high luminosity according to investigations based on parallactic motion, spectrophotometric analysis, and trigonometric parallax. The luminosity of Cepheids of the cluster type, with periods less than a day, has played an important part in the determination of the distances of globular clusters, and in the inferences drawn from that material relative to the size of the galactic system. It has been assumed that the luminosity of cluster type variables is also high, the average median slightly exceeding absolute magnitude zero (Mt. W. Contr. 151, 1917). The basis of that assumption is the period-luminosity curve, as modified by data from Messier 5, Omega Centauri, and other globular clusters.

The comparability in clusters of the magnitudes of blue stars and cluster type variables strongly supports the adopted extension of the period-luminosity curve. It is important, however, to check further this region between the luminosities of the two groups of Cepheids, especially since the high galactic latitudes of many isolated variables of the cluster type and the large proper motions of two of them have been held by some as important evidence of low absolute magnitude. A verification of the high absolute brightness of the short period group has now been obtained through a further study of the variable stars in the Magellanic Clouds.

A small proportion of the thousand variable stars found by Miss Leavitt in the Small Magellanic Cloud are somewhat fainter than the typical Cepheid variables with periods in excess of two days. A preliminary investigation of these fainter stars has been made from a special series of sixteen long-exposure photographs with the Bruce 24-inch telescope at Arequipa. The observations are sufficient to show that thirteen variables have periods less than one day.

The curves are typical for cluster type variables. The mean of the periods is $0^d.64$. The mean of the median magnitudes is 16.1, closely agreeing with 16.2, the median predicted by the modified period-luminosity curve. It appears necessary to conclude, therefore, that the cluster type Cepheids are giant stars in the Small Magellanic Cloud, as previously deduced for the globular clusters and assumed for the galactic system in general.

Harvard College Observatory Bulletin 765.

Astronomie, edited by Prof. J. Hartmann, a volume of the series Die Kultur der Gegenwast (Teubner, Leigzig—640 p.p.) This is not a text book but a series of articles, each complete in itself, written by various leaders in the development of modern astronomy in Germany. The best way to show the scope of the work is to give the various chapter headings and the name of the author of each. These are as follows: 1 The development of the astronomical view of the universe in connection with religion and philosophy—Franz Boll. 2. Time reckoning—F. K. Ginzel. 3. Time measurement—J. Hartmann. 4. Astronomical determination of position (celestial and terrestrial).—L. Ambronn. 5. The expansion of the space concept.—A. von Flotow. 6. Mechanical theory of the planetary system.—J. von Hepperger. 7. Physical investigation of the planetary system.—K. Graff. 8. The physics of the sun.—E. Pringsheim. 9. The physics of the fixed stars, (including nebulae).—P. Guthnick. 10. The sidereal system.—H. Kobold. 11. The relation of astronomy to art and instrumental technique.—L. Ambronn. 12. Gravitation.—S. Oppenheim.

Prof. Hartmann is to be congratulated on securing such collaborators to aid in getting out this volume. The various subjects have been handled in a most interesting fashion but it is to be regretted that there are so few modern illustrations to illustrate the fine text. The book can be recommended as authoritative, up-to-date, and well worth reading by anyone desiring a nontechnical treatment of the subject matter of astronomy.

Relief for Russian Astronomers.—Professor Edwin B. Frost, director of the Yerkes Observatory sends us the following circular letter, which has been addressed to a number of American astronomers. As suggested therein, any who have not received the circular letter may, if they wish to aid in this very worthy cause, send their contributions to Professor Frost.

THE YERKES OBSERVATORY.
Williams Bay, Wis., March 21, 1922.

Dear Colleague:

Inasmuch as we have on our staff Mr. Otto Struve, we are perhaps better informed than other observatories as to the conditions of Russian astronomers and their families at the present time. The severest distress is being felt now and will continue for the next few months. A generous subscription was made at the Swarthmore meeting of the American Astronomical Society last December. This has been sent in the form of food drafts for distribution at Pulkowa Observatory, where we believe there are some twenty families, with an estimated requirement of five $10 food drafts per month. Thus Pulkowa has been provided for, for the immediate present.

We have made out a list of the Russian observatories with an estimate of the number of families dependent upon each institution and the probable amount of food packets, expressed in dollars, that will be required monthly until further notice. A direct appeal having reached us from Kasan, which is in one of the worst famine districts of the list, we at the Yerkes Observatory are providing for their needs. We have assumed that other observatories in this country, many of which were not represented at the Swarthmore meeting, will wish to participate in this effort at relief.

We have no desire in any way to take this out of the hands of the committee which provided for the funds raised at the Swarthmore meeting, but are merely sending this out in the interest of promptness, and we shall be willing to act as intermediary with the American Relief Administration in the matter in so far as other observatories may desire.

The astronomical institutions to which relief should be sent are the following, with the amount of relief required monthly, as nearly as can be estimated on the basis stated above:

Observatory	Amount in Food Draft, Monthly	
Kharkof	$20	
Kasan (Engelhardt)	$20	(provided by Yerkes Obsy.)
Kief	$10	
Moscow (Univ. Obsy.)	$20	
Nicolaijef	$10	
Odessa	$10	
Pulkowa	$50	
Petrograd	$10	
Taschkent	$20	
Simeis	$10	
Rustov and Simferopol	$20	(combined, because Simferopol has no warehouse.)

We hope to obtain information very soon about the members of the Astronomical Society at Nidji Novgorod and the Kasan University, and an able observer at Ekatharinoslaf.

Professor and Mrs. Ceraski were also the subject of special provision from the collection at Swarthmore, which will provide for the immediate present. We are advised here of their movements.

It has been thought possible that some special American observatories, having a large number of persons on their staff, might wish to designate special institutions from the above list which they will desire to aid. It is our intention to have the money sent to institutions, and not to any individuals by name, thus avoiding the uncertainties as to the life and movements of individuals.

To save correspondence in this respect, we would make the following suggestions, which are purely provisional and entirely subject to the wishes of the institutions concerned. These suggestions are merely made so that there can be a personal element in the relations between the institutions named, with an interchange of correspondence, and also in the interests of promptness, which is the most important element in this instance.

American—	Russian—
Mount Wilson	Pulkowa?
Lick	Taschkent
Harvard	Moscow Univ. Observatory (Stratanoff's Institution may not require aid).
Yale	Kharkof
U. S. Naval	Simeis and Nicolaief
Ann Arbor	Rustov
Allegheny	Simferopol (send to Rustov)
McCormick, Va.	Petrograd
Dudley Observatory	Odessa
Princeton and Univ. of Penn.	Kief
Yerkes	Kasan Observatory
Vassar, Wellesley, Smith and Mt. Holyoke	Madame Ceraski, for future

It is suggested that many observatories which we have not included in this list will also wish to send their contributions direct to us. Checks should be made payable to Edwin B. Frost.

The very efficient arangements made by the American Relief Administration (organized by Mr. Hoover and Vernon Kellogg) make it practically certain that there can be no loss of money sent. It will be returned, if delivery cannot be made to the institution or individual specified; and, if delivered, a receipt is given.

G. Van Biesbroeck, O. Struve, Edwin B. Frost.

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